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## Environmental science curriculum for eleventh through twelfth grade classes

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ENVIRONMENTAL SCIENCE CURRICULUM FOR  
ELEVENTH THROUGH TWELFTH GRADE CLASSES

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A Project  
Presented to the  
Faculty of  
California State University,  
San Bernardino

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In Partial Fulfillment  
of the Requirements for the Degree  
Master of Arts  
in  
Education: Environmental Education Option

---

by  
Jenelle Sue Bryan  
June 1998

ENVIRONMENTAL SCIENCE CURRICULUM FOR  
ELEVENTH THROUGH TWELFTH GRADE CLASSES

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A Project  
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by

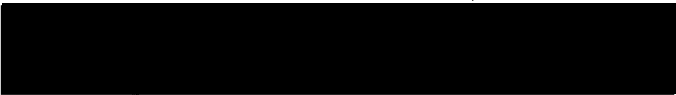
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## ABSTRACT

This environmental science curriculum was developed in order to provide a year-long issue-based environmental course for eleventh through twelfth grade. Topics that are covered in the curriculum will include natural resources, ecological concepts, world biomes, human impact, environmental ethics and health issues. This curriculum uses the constructivist approach to teach environmental knowledge and values thus helping students achieve attitudinal and behavioral changes towards the environment. The curriculum covers required areas of study as outlined in the Science Framework of California Public Schools, Kindergarten Through Twelfth Grade (California Department of Education, 1990).



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## INTRODUCTION

Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, and one that is aware of how to help solve those problems and motivated to work towards their solution.

Stapp et al., p. 30, 1969

Many barriers stand in the way of reaching the goal of producing an environmentally literate population. One such problem is the availability of a hands-on, issue-driven curriculum at the secondary school level. An issue-based curriculum utilizes local issues that affect the students. This allows students to apply the learning process to relevant environmental issues and consider the actions they might take.

In this project, I have created sample units for a year-long curriculum for eleventh through twelfth grade students that meets the requirements set forth in the Science Framework of California Public Schools: Kindergarten Through Grade Twelve (California Department of Education, 1990) and that deals with local issues. The Science Framework recommended that school curriculum begin to focus on increasing the amount of environmental education in all of the content areas being taught. The

Science Framework suggested that students who had some type of environmental experience in their schooling had a more positive attitude towards and were more likely to succeed in school.

With student dropout rates increasing sharply over the past ten years, finding a way to motivate students to want to succeed in school is a necessity (Lungren, 1995). In his survey, he found that in 1995, 71,000 teens failed to complete high school in California. His survey found that two-thirds of the teens that are using drugs and committing crimes and violent acts are dropping out of school. Many of these students could be characterized as at-risk students who are students with high absenteeism and poor grades.

Environmental education has recently been looked at as a possible prevention for the increasing dropout rate for at-risk students (Disinger & Roth, 1992; Stoner, 1990). By implementing an environmental program at the high school level it will be able to target at-risk students along with the general population of the school. This environmental program will provide a subject of interest to at-risk students in the hopes that a connection to school and their environment can be made, thereby, increasing motivation and

relevance of education and reducing the number of student dropouts at the high school level.

Another land mark in the effort to produce an environmentally literate populous is the document "Agenda 21". Agenda 21 was produced by the Plenary in Rio de Janeiro, on June 14, 1992. This was a voluntary action plan to provide an agenda for local, national, regional, and global action into the 21<sup>st</sup> century. Issues addressed in Agenda 21 include that we are confronted with a perpetuation of disparity between and within nations, a worsening of poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystem on which we depend for our wellbeing. Integration of environmental and developmental concerns and paying greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems, and a safer, more prosperous future (as reviewed by Ramphal, 1994). By fulfilling our students' basic needs and giving them hope in the future through educating the students about the issues addressed in Agenda 21, we will be enabling students to be more active in their schooling and in the environment around them.

## LITERATURE REVIEW

In the end, we will conserve only what we love..  
we will love only what we understand..  
we will understand only what we are taught.

Lao-Tsu

The literature review described below supports the need for an environmental program at the high school level. The history of environmental attitudes and actions is examined first. Next, environmental attitudes, knowledge and behavior are discussed. The next section discusses at-risk students. Then, some educational strategies for teaching environmental education are reviewed. Lastly, some of the existing environmental programs are outlined.

### History of Environmental Attitudes and Action

Environmental attitudes and actions and their effect upon the care of the environment have been a controversial topic for politicians, environmentalists and the public. In the latter half of the 19<sup>th</sup> century hunters and people who fish noticed that wildlife was decreasing and were the first to start programs to enhance the habitat for

wildlife. To ensure that they could enjoy their sport each year, various clubs were founded to help regulate the environment and to regulate the various sports impacting the wildlife in that environment. As more people became aware of their immediate environment, initiatives to protect those surroundings were started (Lewis & Zeldin, 1991).

More rescently it is thought that Earth Day 1970 was the start of the current environmental era. Each decade since then has produced identifiable environmental action agendas. In the 1970s, there was the anti-littering campaign and in the 1980s the recycling campaign followed, which helped make the public more aware of environmental problems. The 1990s brought the think locally, act globally green campaign (Gigliotti, 1992).

Environmental education has had many barriers to overcome and it still has many more. In 1970, The United States Congress passed the National Environmental Education Act. It was never fully funded and eventually ended in 1981. In 1990, the 20<sup>th</sup> anniversary of Earth Day was upon us; Congress again passed the National Environmental Education Act of 1990. This new act was to "establish and



support a program of education on the environment" (Lewis & Zeldin, 1991, p. 6).

Why was it necessary for Congress to introduce the National Environmental Education Act again? Congress felt that the efforts "to inform and educate the public concerning the natural and built environment and environmental problems are not adequate" (Lewis & Zeldin, 1991, p. 7). The Act stated that the federal government working through the Environmental Protection Agency (EPA) needed to establish programs through business, industry, private, public and educational departments to enhance environmental education programs (Lewis & Zeldin, 1991; Reilly, 1991).

The National Environmental Education Act signed into law in 1990 had two broad goals: (1) to increase environmental literacy which is the capacity to perceive and interpret the relative health of environmental systems, and take appropriate actions to maintain, restore, or improve the health of those system; and (2) to encourage people to pursue careers in math, science, engineering, communication and other fields essential to future environmental improvement (Disinger & Roth, 1992).

Another document with similar goals was Agenda 21. Agenda 21 was produced by the Plenary in Rio de Janeiro, on June 14, 1992. It is a voluntary action plan to provide an agenda for local, national, regional, and global action into the 21<sup>st</sup> century. Agenda 21 addressed environmental problems and promoted sustainable development (Ramphal, 1994). It addressed four major issues described in four sections as follows:

Section 1 - Social and economic dimensions. This section includes suggestions for sustainable development cooperation, increased poverty consumption, demographics, health, human settlement, and integration of environment and development in decision making.

Section 2 - Conservation and management of resources for development. This section includes suggestions for atmospheric protection, management of land resources, deforestation, desertification, drought, mountains, agriculture, biological diversity, biotechnology, oceans, freshwater resources, toxic chemicals, hazardous wastes, solid wastes, and radioactive waste.

Section 3 - Strengthening the role of major groups. This section includes suggestions for increased participation in sustainable development efforts of major

social groups: women, youth, indigenous people, non-governmental organizations, local authorities, trade unions, business and industry, scientific and technological communities and farmers.

Section 4 - Implementation Strategy. This section makes reference to financial resources, technology transfer, cooperation and capacity, building, science, education, public awareness, and training, institutional arrangements, legal instruments and mechanisms and information collection, analysis and dissemination.

In accordance with Agenda 21, the National Forum for Partnership Supporting Education about the Environment (1994) produced a document called Education for Sustainability: An Agenda for Action to help meet the goals of Agenda 21. This document was aimed at a lifelong learning process that leads to an informed and involved citizenry having creative problem solving skills, scientific and social literacy, and the commitment of individuals to engage in responsible and cooperative actions. These actions are considered important in insuring an environmentally sound and economically prosperous future.

During the meeting of people from business, education, government, and various organizations at the National Forum on Partnerships Supporting Education about the Environment (1994), successful efforts for implementing education for sustainability were recognized to depend on six core themes: (1) lifelong learning, (2) interdisciplinary approaches, (3) systems thinking, (4) partnerships, (5) multicultural perspectives, and (6) empowerment.

Rockland and Fletcher (1994) found that the public as a whole felt that environmental protection and economic growth go hand in hand. They found that 100 million Americans enjoy outdoor activities and spend more than \$300 billion annually on outdoor activities. It is estimated that by the year 2000 more than \$400 billion will be spent on outdoor activities annually. Rockland and Fletcher also found that most Americans hold a conservationist's view towards the environment. That is, they believe that through sound management we can both protect and enjoy the use of natural resources. Only a small percent of population held the preservationist's view, which is the belief that the only way to protect the environment is to make it off limits to the public.

Other explanations may be given for the environmental views of the public. Kastenholz and Erdmann (1994) found that one of the problems with people's attitudes towards the environment can be directly linked to the destruction of cultural identities and ethical values. With increasing problems such as drug use, violence and vandalism, people are less concerned about the environment and more concerned with their own wellbeing. Those that are concerned are subjected to highly televised environmental disasters, causing them to become desensitized to environmental problems. Some attempts have been made to reverse this desensitizing effect. Some of these attempts have been to include an ecological market economy, which is an economy based on recycling, profit incentives for saving the environment and tax breaks to large industry who become environmentally active. Other attempts have been to enact environmental legislation, such as laws passed to insure that businesses and the public protect the environment, and to foster creation-centered environmental ethics (safeguards God's creation). Still others believe that by introducing spiritual consciousness building techniques which focus on teaching people how to become connected to the environment we can help counteract the hopelessness and

despair that many people feel due to the disintegration of society (Kastenholz & Erdmann, 1994).

### Environmental Attitudes, Knowledge and Behavior

An important environmental education is to motivate knowledgeable individuals to work towards a more livable world through the understanding that the human relationship with the environment is a cause and effect relationship and that we are accountable for our actions and the impact upon the environment (Zimmermann, 1996).

Factors that contribute to responsible environmental behaviors have been the topic of intensive study among environmental educators for many years. Rubba and Wiesenmayer (1988) found that responsible environmental behavior may be attributed to four main factors:

1. Knowledge of environmental issues.
2. Knowledge of specific action strategies that might be applied to resolve an environmental issue.
3. The ability to take action on environmental issues.
4. The possession of certain affective qualities and personality attributes.

Environmental sensitivity, which refers to an empathetic view of the environment and its problems and issues, is also noted as being critical to an individual's willingness to investigate and take action on environmental issues (Hungerford & Volk, 1990; Rubba & Wiesenmayer, 1988).

One overwhelming problem that Rockland and Fletcher (1994) and Gigliotti (1992) found was the lack of knowledge by the public about most environmental problems. Most people are aware that there are problems but do not understand the connection between themselves and the problem (Fingers, 1993). This was also shown to be the case in high school students. Gambo and Switzky (1996) showed that high percentages of high school students in four countries, United States, Australia, England, and Israel, were aware of environmental problems and the need to protect our environment. However, the students' level of factual and conceptual knowledge was judged to be less than adequate. They found that most high school seniors possessed a limited, elementary comprehension of environmental problems and lacked the necessary understanding to go beyond the common recognition of an issue. The students tended to display less than adequate

environmental knowledge needed to grasp the consequences of environmental problems or develop any solutions to those problems. Gambo and Switzky (1996) defined this type of knowledge found in high school students as "inert knowledge" (1996, p. 30). This is knowledge that can usually be recalled when people are explicitly asked to do so but it is not used spontaneously in problem solving even though it may be relevant to the problem. This lack of environmental knowledge and the ability to understand the issues seemed to be a reoccurring theme in several studies done with high school students.

Three of those studies found those high school students in Illinois, New York, and Australia also displayed similar attitudes and knowledge towards environmental issues (Hausbeck, Milbrath & Enright, 1992; Jordan, Hungerford & Tomera, 1984; Keen, 1990).

Volk (1993) noted that ecological literacy was also important to sound environmental decision making. She found that in order to approach issue resolution in an informed and responsible manner, the learner must be able to identify the ecological consequences related to the issues and to their proposed solutions.



Volk (1993) found that throughout the learners' formal education, they should experience both classroom and field experiences centered on topics such as individuals and populations; interactions and interdependence; environmental influences and limiting factors, energy flow and nutrients cycling; communities and ecosystems; homeostasis; succession; humans as members of ecosystems; and the ecological implications of humans as members of ecosystems. She concluded that an environmental education curriculum should contain the following areas: have ecological knowledge to make ecological decisions, understand that individual and collective actions influence our quality of life and quality of the environment, obtain the knowledge and skills necessary to investigate and evaluate issues and solutions, and have skills necessary to take a positive environmental action. This would show the need to implement educational programs in order to educate the people on how they can help be more environmentally aware so that sound management of our natural resources can be accomplished.

Miller and Keller (1991) found that the language used to define environmental issues affects environmental attitudes. They also found that the public views on

environmental problems vary from those opinions held by experts in the field. Higher levels of concern and understanding were generated when issues were explained to the public in common language that was void of technical words. When environmental education classes are taught in terms too technical, the knowledge and understanding of the environment that is trying to be conveyed are often lost.

Many times the information reported by the news reporters uses technical terms to convey devastating environmental information. Greenberg, Sandman, Sachsman, and Salomne (1989) showed that 71% of the population got some or all of its information on environmental issues from the television news. The coverage of environmental issues on network news is only a small percent of the total news, and environmental issues may be missing from the news on many occasions. According to researchers the stories presented by the media usually represent a biased, one-sided opinion of that particular issue. Thus public opinion is usually formed before all of the information or facts are known.

Another problem with receiving most of their environmental knowledge from the television is the desensitization that occurs from being bombarded with

environmental disasters over and over again. Greenberg, et al. (1989) found that many people become desensitized to the environmental problems that were reported on television. The viewers believed that they were helpless against these televised disasters causing them to make no effort to be environmentally aware. Within the disintegration of the family environment there is little emphasis on education, and the feeling of hopelessness is compounded by the looming environmental problems perceived from television.

Orr (1990, 1996) pointed out that education is no guarantee of decency, prudence, or wisdom. Educating the public with environmental knowledge does not guarantee that people will act in a responsible manner. Cortese (1991) stated that governments have traditionally relied upon command and control regulations to protect the environment. However, the diverse and unpredictable nature of human activities, which are causing environmental transformation and degradation, clearly require that we use every possible tool to change the behavior of individuals and institutions.

## Educational Strategies

Leeming, Dwyer, Porter, and Cobern (1993) concluded that the success of environmental educational programs in changing human attitudes has been limited. The increase of environmental knowledge in the general public has been successful, but the ability to act upon this knowledge has been less than forthcoming. A new strategy, therefore, must be developed that will allow students to gain knowledge about the environment in a way that affects their behavior and attitudes about the environment.

One strategy has been provided by Adams, Biddle, and Thomas (1988) who identified five ways that environmental science teaching should be incorporated into school curriculum.

The five areas are:

1. Outreach programming of environmental science facilities outside the classroom.
2. Community resources and interpretive personnel.
3. Methods of developing on-campus study areas.
4. Environmental science teaching strategies that are activity and inquiry oriented.
5. Supplemental environmental science materials from private and government agencies.

They found that if these strategies are incorporated within an environmental program, then the success of that program will be increased. This type of teaching strategy helps to insure that the students not only have classroom experience but that they also take this knowledge outdoors and experience it first hand.

The American Association for the Advancement of Science has initiated Project 2061, a multiphase effort designed to help the nation achieve scientific literacy (1993, pp. XI, 284). Project 2061 was started in the 1985, and is named after the year when comet Halley returns to our solar system. Project 2061 has incorporated effective techniques for teaching science with the premise that science education should be rigorous but fun. These include hands-on, experiential, laboratory-based science that explore real issues. Teachers should emphasize topics that are interesting and relevant to the students who will have to make decisions about scientific issues influencing their health, the health of the growing population, and the health of the planet (Rutherford & Ahlgren, 1990, p. 204-205).

The California Department of Education has identified appropriate teaching strategies through its Science

## Framework of California Public Schools: Kindergarten

Through Grade Twelve (1990). The Science Framework noted that socially sensitive issues belong in the classroom and that conservation should be part of the classroom curriculum. Students should be taught to evaluate various positions on issues, with an understanding of the impact of each position on the environment. They should also understand that technology has often brought, along with its advances, some undesirable secondary effects such as pollution. Students also need to understand that population growth affects the planet and that some populations use more of the resources than others. Students should be educated about these perspectives in order to help them make informed judgements about their habits and priorities and to help them set policies for the next generation.

Munson (1994) pointed out that students hold many ecological misconceptions. The constructivist model has been put forth by many educators as one strategy to be used in teaching environmental education to help overcome these misconceptions. Klein and Merritt (1994) outlined the four main areas of constructivist teaching and how it is used in the classroom. This strategy incorporates many of the

strategies that were introduced by Project 2061 (American Association for the Advancement of Science, 1993) and the Science Framework of California Public Schools:

Kindergarten Through Grade Twelve (California Department of Education, 1990). The four main components of the constructivist approach are:

1. Introduction of a real life problem by the student or teacher for the student to solve.
2. Student centered instruction facilitated by the teacher.
3. Productive group interaction during the learning process.
4. Authentic assessment and demonstration of student progress by the student.

### Environmental Programs

A variety of environmental education programs, Kindergarten to twelfth grade, have been studied. These programs have had a varying degree of success. Singletary (1992) studied environmental education programs in the Chicago area, which focused on high school and middle school students. In his study the main problem he found was that the teachers had no formal environmental education training and thus the information being taught to the students varied drastically from school site to school

site. Using their own curriculum, most of the teachers were teaching facts, but not teaching the students how to use this knowledge to solve environmental problems. The students had acquired sufficient knowledge in this area, but these programs had little effect on changing student's behavior or their attitudes.

Welsch (1991) provided information on how environmental education had been infused throughout the curriculum in Wisconsin. All of the curricular areas touched upon environmental education, but there was no data in his paper as to how it affected the attitudes or behavior of these students.

Within California many environmental education type programs exist; however, they are mainly at the elementary or middle school level (Desmond, 1996-97). In a recent survey Desmond found that the most popular type of environmental experience, the school garden, was found predominantly at the elementary level. The survey found that school gardens most often built social skills, created connectivity to the surroundings, enhanced environmental responsibility, and motivated children to make healthy food choices and fostered a better understanding and appreciation of where food comes from. Several schools in



California use these gardens to enable hands-on experiences in nature in order to help connect students to their environment.

Kimbark Elementary School in San Bernardino, California, is a local example of one of these schools. Kimbark has had a school garden along with an extensive environmental education program for many years. The environmental program reaches across the entire curriculum and continues throughout all grade levels. It has promoted more student involvement and school pride since its implementation (Stoner & Overbey, 1989).

Several environmental programs exist, but many are missing the action element needed in the program. Recently Project WILD produced an environmental action guide aimed at enabling students to take action on local issues (Stoner, 1995). Several success stories across the United States were included in this guide.

### At-Risk Students

At-risk students may be characterized as students with high absenteeism and poor grades. They tend to have low math and reading scores and have a lack of identification with their school or a sense of not belonging. They fail

to see relevance in education when dealing with daily life experiences and usually display disruptive behavior in the classroom. Many display rebellious attitudes towards authority and are verbally deficient thus having difficulty expressing feelings other than anger. They often find school boring and useless. These students may show low self-esteem and motivation or commitment. They demonstrate weak organizational skills and tend to have poor peer-group relationships, which often leads to disagreements and aggressive behavior. They do not have respect for authority because they have low self-respect towards themselves. These students can be withdrawn or appear to be shy. They usually have health problems, poor nutrition and hygiene along with an overall bad attitude towards life. These students may be involved with drugs, alcohol or gangs as a way of escaping from life or to help them feel like they belong. They may be self-centered and take no responsibility for their own actions (Stoner, 1990). Because of the increase in at-risk students within a school community, they must also be considered when constructing new programs.

In considering the literature review, this author has developed a model for an environmental education course

suitable for the high school level. In following the recommendations of the literature review this curriculum will follow the constructivist approach in teaching environmental concepts necessary to help the students achieve attitudinal and behavioral changes towards the environment.

## GOALS AND OBJECTIVES

The overall goal of this project was to create an environmental science curriculum that will enable high school students, eleventh through twelfth grade at Jurupa Valley High School, to make informed environmental decisions. This curriculum has student and teacher objectives that will be covered during the yearlong course.

### Teacher Objectives

The teacher will provide lessons and activities that enable the learner to:

1. Acquire ecological knowledge that will permit him/her to make ecologically sound decisions with respect to environmental issues.
2. Develop a conceptual awareness of how individual and collective behavior influences the relationship between quality of life and quality of environment.
3. Develop the knowledge and skills needed to permit them to investigate environmental issues and evaluate alternative solutions for resolving issues.
4. Develop those skills needed for them to take positive environmental action for the purpose of resolving or helping to resolve environmental-related issues.

### Student Objectives

The student will demonstrate the following as a basis for assessment:

1. Knowledge of relevant environmental concepts.
2. Knowledge of environmental problems and issues.
3. Knowledge of action strategies that may be used for resolving issues.
4. Concern for the quality of the environment.
5. Belief that their actions can make a difference.
6. Commitment to take action.
7. Experience in action-based activities.

## DESIGN OF PROJECT

A recent comprehensive framework for planning the content of curricula for environmental learning (Disinger, 1993), along with the Science Framework of California Public Schools: Kindergarten Through Grade Twelve (California Department of Education, 1990), have suggested five broad topic areas as appropriate curricular material for a secondary environmental science course. These five areas are Natural Resources, Ecological Concepts, World Biomes, Human Impact, and Environmental Ethics. These topics were utilized as a framework to create lessons for this project.

In order for the California Department of Education to consider a class as a college preparatory course, it must provide material to cover at least 80% of the Science Framework questions and provide an opportunity for the students to have laboratory activities at least 25% of the time (California Department of Education, 1990). The five topics selected for this course, along with the relevant lessons, meet these requirements. The five topic areas and relevant subtopics are listed in Table 1.

These topics can be taught as issue-based lessons using the following methods: discussion, laboratory

exercises, field trips, and library research projects and reports. Guest speakers, audio-visuals, and homework are also included.

Table 1

California Science State Framework Required Subject Areas

	TOPIC	SUBTOPICS
1	Natural Resources	soil and water; plants and animals.
2	Ecological Concepts	food webs and energy flow; biodiversity; adaptation and habits; succession; habitats; interdependence; population dynamics; solid earth systems; and geological time.
3	World Biomes	tropical forests; temperate forests; deciduous forests; coniferous forests; oceans; reefs and coastlands; tundra and polar regions; grasslands; meadows and prairies; rivers; ponds; lakes and wetlands.
4	Human Impact	land use; endangered species; biodiversity and habitat loss; energy production; energy use; energy conservation; population growth; deforestation; global warming; the greenhouse effect; and acid rain.
5	Environmental Ethics and Health Issues	effects of pollution on children's development; increase in health problems; attitudes towards the environment; technology and the environment; and local issues.

The teaching method emphasizes constructivist components. This method recognizes that students have misconceptions and differing knowledge levels about their environment (Brooks, 1990; Munson, 1994). A constructivist lesson structure has four main parts: (1) introduction of a real life problem; (2) student centered instruction facilitated by the teacher; (3) productive group interaction during the learning process; and (4) authentic assessment and demonstration of student progress (Klein & Merritt, 1994).

The lessons are arranged into units consisting of four lessons each, and are designed to incorporate the four constructivist components. Each unit has a real life, issue-based application along with a hands-on activity which has a productive group component. The units are designed so that the first lesson gives the students background information about the topic. The second lesson provides more detailed information necessary for the students to understand the issue that will be introduced. The third lesson introduces the two sides of the local issue, and the fourth lesson provides the student with the opportunity to take action on that issue. Within each unit, the lessons are designed to encourage students to find



answers for the tasks they undertake about an environmental topic. Each lesson is set up so that the teacher is provided with the necessary background information to answer questions that students may generate during the lesson. The background information in the lessons has been gathered from a variety of sources, such as Project WET, the Internet and textbooks. Each lesson has four sections to it. A focusing section is designed to direct the student's attention in the right direction. Next, the finding out section is designed for students to explore possible answers to the focus topic question. A bridging activity is then provided, which has the students use the information they gathered to produce an informative product that the teacher can use to assess the type of knowledge they have gained from the experience.

One essential part to this unit design is to first introduce a local issue first in order to motivate the students and interest them in the problem. The issue introduced in the sample units range from local issues for the Inland Empire or Southern California, to global issues that affect everyone (such as ozone depletion). When introducing the local or global issues, the students commonly vocalize many questions and concerns. These

questions and concerns may be used to start the constructivist lesson strategy.

The purpose for developing this program was to provide high school students with the opportunity to take a yearlong course that could assist them in developing their awareness, knowledge, and commitment to the environment. When the course is completed they will be able to make informed decisions and to take responsible actions toward the environment.

For each of the five topic areas, a list of activity resource guides providing lessons and hands-on activities has been provided in Appendix C. In Appendix D a resource guide for each of the five topic areas has been provided which lists names and addresses where these activities may be purchased. Integrated sample units have been provided which may be used for several of the sub-topic areas located in Appendix B. However, because these are only a small selection of possible units that would be taught during the yearlong course, not all of the student and teacher objectives have been addressed by these sample units. The goal of the sample units are to familiarize the teacher with a specific style that utilizes the constructivist method.

## IMPLICATIONS FOR EDUCATION

Changes in education are often greeted with reluctance and reservations by teachers, parents and administrators. Ham, Rellergert-Taylor, and Krumpe (1987) found that many barriers existed to the full implementation of environmental education in the school system. These barriers are as follows: conceptual barriers stemming from the lack of consensus about the scope and content of environmental education; logistical barriers stemming from a perceived lack of time, funding, instructional resources, and suitable class sizes; educational barriers stemming from teachers' misgivings about their own competence to conduct environmental education programs; and attitudinal barriers stemming from teachers' attitudes about science and environmental education instruction.

Integrated units that cover several of the sub-topic areas have been included. Even though this curriculum was developed for one target high school, the author feels that this curriculum would be useful if implemented at other high schools in the Inland Empire area.

## APPENDIX A

### College Preparatory Requirements

## COLLEGE PREPARATORY REQUIREMENTS

The Science Framework of California Public Schools (California Department of Education, 1990) has outlined specific areas that secondary school curriculum must meet in order for a class to qualify as a college preparatory class. These college preparatory requirements are referred to as the A-F requirements in the Science Framework of California Public Schools. To meet these college preparatory requirements, the following environmental science course would be offered.

Course Title:	AP Environmental Science
Department:	Science
Course Length:	1 Year
Prerequisite:	Instructor's Approval and 1 year of life science. Taken either at the middle or high school level.
Target Group:	11 <sup>th</sup> - 12 <sup>th</sup> grade students who excel in biology.

Course Description: The Advanced Placement Environmental Science course provides students with the scientific principles, concepts, and methodologies required for understanding the relationships within the natural world. It gives them the ability to identify and analyze environmental problems, both natural and human-made, and to evaluate the relative risks associated with these problems.

They will be able to examine alternative solutions for resolving and/or preventing environmental problems.

Advanced Placement Environmental Science is an interdisciplinary science course combining geology, biology, environmental studies, environmental science, chemistry, and geography.

The Advanced Placement Environmental Science course is designed to be the equivalent of a one semester introductory college course in Environmental Science. Advanced placement courses are for those students who wish to pursue college-level studies while still in secondary school. Currently at the high school level, a program called AVID exists, which targets college capable students that are in non-supportive environments. This program allows students to get extra help to insure that they make it into and through college. College preparatory courses allow AVID students the opportunity to advance towards college placement. Universities recognize this achievement by granting college credit to those students who perform satisfactorily on the advanced placement examination given in May of each year.

Expected student learning outcomes will be evaluated in the following manner, emphasizing authentic testing (Haury, Heimlich, & Norton, 1993; Marcinkowski, 1994):

1. The student's performance is observed in the course of her/his everyday activity.
2. The student is presented with assignments; her/his performance in carrying out those assignments is observed.
3. The student is presented with tasks to complete in a test-like setting; her/his performance in carrying out those tasks is observed.
4. The student is required to demonstrate knowledge of specific areas by producing a portfolio that contains two pieces of work for each area in which the student will demonstrate his/her knowledge of that subject.
5. The student is evaluated on how successful he/she is at retrieving information from the Internet.

Students who successfully complete this course will demonstrate the following abilities:

1. They will be able to identify local environmental issues that affect their community.
2. They will be able to apply environmental science knowledge directly to local issues.
3. They will use higher thinking skills to analyze and evaluate environmental issues in order to suggest possible solutions.
4. They will be able to display communication skills by showing that they understand both sides of an environmental issue and can then present their views in a persuasive manner.
5. They will be able to display goal-setting and attainment skills by developing a goal for action on an environmental issue, and then take steps to develop a program to reach these goals.

An important part of this environmental class is the curricular material used in order to present the issues in

the constructivist platform (Marshall, 1993). The textbook being used for this class is A Global Concern, 4<sup>th</sup> edition (Cunningham, & Woodworth Saigo, 1997). This textbook provides background information on several topics, some labs, and offers guidance on involvement in local action issues. There will also be supplemental material used, in order to give the best information on local issues for the five main areas being covered here.

Once students have finished the course they will demonstrate knowledge of the scientific method, proper equipment use, and the ongoing relationship between humans and the earth's natural resources. They will demonstrate this by understanding that there may be many different approaches to the same problem. They will be able to use the scientific method to perform experiments that will help the student make a reasonable decision on the problem being presented.

Students will also be able to understand the course content and apply these environmental principles appropriately. The student will demonstrate their knowledge of ecological organization, interactions within communities and its affects on others, and be able to analyze population growth and recognize environmental



problems that are made by humans. Students will be able to apply these principles to individual, social and global issues.

The five topics, along with their subtopics, have been correlated with the Science Framework of California Public Schools (California Department of Education, 1990) to demonstrate that they meet the required areas within the Science Framework (see Table 2). Table 2 displays the total number of times that each environmental topic is potentially addressed in the curriculum related to the questions from the California Science Framework.

In Table 3, the five topics (Natural Resources, Ecological Concepts, World Biomes, Human Impact, Environmental Ethics and Health Issues) are broken down into the subtopics which will be covered in that area. Table 3 shows the correlation between the questions that the California State Framework requires college prep curriculum to cover, and the California State Framework questions the Environmental Science Curriculum addresses.

## Environmental Science Framework Questions

Questions from Science Framework		Natural Resources - Soil and Water, Plants and Animals	Ecological Concepts - Food Web and Energy Flow, Biodiversity, Adaptation, and Habits, Succession, Habitat, Interdependence, Population Dynamics, Earth's Systems, Geological Time, Solid Earth	World Biomes - Tropical forests; Temperate; Deciduous; Coniferous Forests; Oceans; Reefs; and Coastlands; Tundra and Polar regions; Grasslands; Meadows; and Prairies; Rivers; Ponds; Lakes; and Wetlands	Human Impact - Land use; Endangered Species; Biodiversity; Habitat loss; Energy Production; Use; Conservation; Population Growth; Deforestation; Global Warming; the Greenhouse Effect; and Acid Rain	Environmental Ethics and Health Issues - Effects of Pollution on Children's Development; Increase in Health Problems; Attitudes Towards the Environment; Technology and the Environment
<b>Living Things</b>						
1. What are the characteristics of life?	1		3			1
2. How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?	8		3			3

Table 2 (cont.)

Questions from Science Framework	Natural Resources - Soil and Water, plants and Animals		Ecological Concepts - Food Web and Energy Flow; Biodiversity; Adaptation; and Habits; Succession; Habitat; Interdependence; Population Dynamics; Earth's Systems; Geological Time; Solid Earth		World Biomes - Tropical forests; Temperate; Deciduous; Coniferous Forests; Oceans; Reefs; and Coastlands; Tundra and Polar regions; Grasslands; Meadows; and Prairies; Rivers; Ponds; Lakes; and Wetlands		Human Impact - Land use; Endangered Species; Biodiversity; Habitat loss; Energy Production; Use; Conservation; Population Growth; Deforestation; Global Warming; the Greenhouse Effect; and Acid Rain		Environmental Ethics and Health Issues - Effects of Pollution on Children's Development; Increase in Health Problems; Attitudes Towards the Environment; Technology and the Environment	
	3. What are the relationships of living organisms, and how are living things classified?	4	2	1						
	4. How do humans interact with other living things?	5	2		5	1				
	<b><u>Cells, Genetics &amp; Evolution</u></b>									
	5. What are cells?				2	10				
	6. What are cell components, structures and their functions?				2	4				

Table 2 (cont.)

Questions from Science Framework	Natural Resources - Soil and Water, Plants and Animals		Ecological Concepts - Food Web and Energy Flow; Biodiversity; Adaptation; and Habits; Succession; Habitat; Interdependence; Population Dynamics; Earth's Systems; Geological Time; Solid Earth		World Biomes - Tropical forests; Temperate; Deciduous; Coniferous Forests; Oceans; Reefs; and Coastlands; Tundra and Polar regions; Grasslands; Meadows; and Prairies; Rivers; Ponds; Lakes; and Wetlands		Human Impact - Land use; Endangered Species; Biodiversity; Habitat loss; Energy Production; Use; Conservation; Population Growth; Deforestation; Global Warming; the Greenhouse Effect; and Acid Rain		Environmental Ethics and Health Issues - Effects of Pollution on Children's Development; Increase in Health Problems; Attitudes Towards the Environment; Technology and the Environment	
	7.How do they grow?		2				1		3	
	8.What is the biochemical basis of life and metabolism?						3		3	
	9.How are the characteristics of living things passed on through generations?									
	10.How does heredity determine the development of individual organisms?						4		3	
	11.How has life changed and diversified through time?		14		1		1		1	

Table 2 (cont.)

Questions from Science Framework	Natural Resources - Soil and Water, Plants and Animals				
	Ecological Concepts - Food Web and Energy Flow, Biodiversity; Adaptation; and Habits; Succession; Habitat; Interdependence; Population Dynamics; Earth's Systems; Geological Time; Solid Earth				
	World Biomes - Tropical forests; Temperate; Deciduous; Coniferous Forests; Oceans; Reefs; and Coastlands; Tundra and Polar regions; Grasslands; Meadows; and Prairies; Rivers; Ponds; Lakes; and Wetlands				
	Human Impact - Land use; Endangered Species; Biodiversity; Habitat loss; Energy Production; Use; Conservation; Population Growth; Deforestation; Global Warming; the Greenhouse Effect; and Acid Rain				
	Environmental Ethics and Health Issues - Effects of Pollution on Children's Development; Increase in Health Problems; Attitudes Towards the Environment; Technology and the Environment				
	12. What processes and patterns characterize the evolution of life?		6		1
	<b>Ecosystems</b>				
	13. What are ecosystems and how do organisms interact in ecosystems?	14	6	17	4
	14. How do ecosystems change?	3	8	5	
	15. How does energy flow within an ecosystem?	1	9	1	1
	16. What are the responsibilities of humans towards ecosystems?	23	1	6	40
					13

## California Science Framework Subtopics

In the following Table 3, each of the five topics are broken down into subtopics that will be taught for each topic area. The California Science Framework questions are then correlated to each of the subtopic areas. An "x" represents a subtopic that corresponds to one of the California Science Framework questions. Each subtopic is then addressed by a series of lessons that are designed to answer the questions marked for that subtopic from the California Science Framework. An example of this would be the topic "natural resources," and the subtopic "animals." The three questions from the California Science Framework for that subtopic are: "what are the characteristics of living things," " what are the relationships of living organisms," and "how are living things classified?" The integrated units are designed to answer the questions from all topic areas that the unit covers.

Table 3

## Natural Resources

Questions from Science Framework	Natural Resources - Plants	Value of Trees to Wildlife	Photosynthesis	Grasslands, Prairies and Meadows	The Desert	Arctic Tundra	Rain Forest	Timber Forest	Pollution	Pesticides	Fires	Harvesting Trees	Value of Plants	
<b><u>Living Things</u></b>														
1. What are the characteristics of life?														
2. How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?	x	x		x	x	x	x	x						
3. What are the relationships of living organisms, and how are living things classified?														
4. How do humans interact with other living things?									x	x	x	x	x	
<b><u>Cells, Genetics and Evolution</u></b>														
5. What are cells?														
6. What are cell components, structures and their functions?														
7. How do they grow?														
8. What is the biochemical basis of life and metabolism?														

Table 3

## Natural Resources

Questions from Science Framework	Natural Resources - Plants	Value of Trees to Wildlife	Photosynthesis	Grasslands, Prairies and Meadows	The Desert	Arctic Tundra	Rain Forest	Timber Forest	Pollution	Pesticides	Fires	Harvesting Trees	Value of Plants	
9.How are the characteristics of living things passed on through generations?														
10.How does heredity determine the development of individual organisms?														
11.How has life changed and diversified through time?														
12.What processes and patterns characterize the evolution of life?														
<u>Ecosystems</u>														
13.What are ecosystems and how do organisms interact in ecosystems?			x	x	x	x	x							
14.How do ecosystems change?														
15.How does energy flow within an ecosystem?		x												
16.What are the responsibilities of humans towards ecosystems?								x	x	x	x	x		



Table 3

## Natural Resources

Questions from Science Framework	Natural Resources - Soil and Water	Soil Composition	Soil as a Habitat for Animals	Soil as it is Used for Building	Soil and Plant Dependency on Soil	Soil and Farming	Degradation of Groundwater	Conservation of Groundwater and Drinking Water	Water Cycle	Oceans and Pollution	Water and Water Runoff	Water and Fertilizers	Water and Erosion	Chemicals in our Soils and Waters
<b><u>Living Things</u></b>														
1.What are the characteristics of life?														
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?														
3.What are the relationships of living organisms, and how are living things classified?														
4.How do humans interact with other living things?														
<b><u>Cells, Genetics and Evolution</u></b>														
5.What are cells?														
6.What are cell components, structures and their functions?														
7.How do they grow?														
8.What is the biochemical basis of life and metabolism?														

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9.How are the characteristics of living things passed on through generations?														
10.How does heredity determine the development of individual organisms?														
11.How has life changed and diversified through time?														
12.What processes and patterns characterize the evolution of life?														
<u>Ecosystems</u>														
13.What are ecosystems and how do organisms interact in ecosystems?	x	x	x					x	x					
14.How do ecosystems change?								x						
15.How does energy flow within an ecosystem?														
16.What are the responsibilities of humans towards ecosystems?				x	x	x	x			x	x	x	x	x

Table 3

## Natural Resources

Questions from Science Framework	Natural Resources - Animals	Aves/Birds	Regional Endangered Species	Endangered Species	Wild Animals	Zoos and Circuses	Predators Among Us	Desert Animals	Insects, How They Help/Harm the Environment	Animal Reserves	Pesticides and the Effect on Animals	Chemicals in Our Environment	Threats to Wildlife	Animals of the Sea	Affects of Fertilizers, Pesticides and Pollution in the Ocean	Fish-Contamination	Animal Cruelty
<b><u>Living Things</u></b>																	
1.What are the characteristics of life?	x																
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?		x															
3.What are the relationships of living organisms, and how are living things classified?	x	x					x							x			
4.How do humans interact with other living things?																	
<b><u>Cells, Genetics and Evolution</u></b>																	
5.What are cells?																	
6.What are cell components, structures and their functions?																	
7.How do they grow?																	
8.What is the biochemical basis of life and metabolism?																	

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## Natural Resources

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9.How are the characteristics of living things passed on through generations?																	
10.How does heredity determine the development of individual organisms?																	
11.How has life changed and diversified through time?																	
12.What processes and patterns characterize the evolution of life?																	
<u>Ecosystems</u>																	
13.What are ecosystems and how do organisms interact in ecosystems?							x		x	x				x			
14.How do ecosystems change?			x	x													
15.How does energy flow within an ecosystem?																	
16.What are the responsibilities of humans towards ecosystems?			x	x	x	x	x		x	x	x	x	x	x	x	x	x

Table 4

## Ecological Concepts

Questions from Science Framework	Ecological Concepts - Food Webs and Energy Flow	Food Cycle	Plankton and Fertilizer and its Effects on the Food Web	Predator/Prey	Carbon Cycle and Earthworms	Scavengers	Decomposers	How Soil Regains Nutrients Naturally	Energy Flow in a Community	Human Contributions			
<b><u>Living Things</u></b>													
1.What are the characteristics of life?													
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?													
3.What are the relationships of living organisms, and how are living things classified?													
4.How do humans interact with other living things?													
<b><u>Cells, Genetics and Evolution</u></b>													
5.What are cells?													
6.What are cell components, structures and their functions?													
7.How do they grow?													
8.What is the biochemical basis of life and metabolism?													

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9.How are the characteristics of living things passed on through generations?													
10.How does heredity determine the development of individual organisms?													
11.How has life changed and diversified through time?													
12.What processes and patterns characterize the evolution of life?													
<u>Ecosystems</u>													
13.What are ecosystems and how do organisms interact in ecosystems?					x								
14.How do ecosystems change?			x	x									
15.How does energy flow within an ecosystem?	x	x	x	x	x	x	x	x	x				
16.What are the responsibilities of humans towards ecosystems?										x			

Table 4

## Ecological Concepts

Questions from Science Framework	Ecological Concepts - Biodiversity, Adaptation and Habits	Animal Camouflage	Concealing Coloration	Disruptive Coloration	Disguise and Mimicry	Masking and Concealment of the Eyes	Animal Family Dynamics in the Wild	Social Behaviors	Animal Behaviors	Adaptation of Animals in a Changing Environment	Environmental Changes Due to Seasonal Changes and Pollution	Birds that have adapted to the urban environments	Adaptation of Plants in Urban Environments	Animal Behavior and Overpopulation	Survival of the Fittest
<b><u>Living Things</u></b>															
1.What are the characteristics of life?															
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?															
3.What are the relationships of living organisms, and how are living things classified?															
4.How do humans interact with other living things?															
<b><u>Cells, Genetics and Evolution</u></b>															
5.What are cells?															
6.What are cell components, structures and their functions?															
7.How do they grow?															
8.What is the biochemical basis of life and metabolism?															

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9.How are the characteristics of living things passed on through generations?															
10.How does heredity determine the development of individual organisms?															
11.How has life changed and diversified through time?	x	x	x	x	x	x					x	x	x		
12.What processes and patterns characterize the evolution of life?		x	x	x	x	x									
<u>Ecosystems</u>															
13.What are ecosystems and how do organisms interact in ecosystems?		x					x	x	x						
14.How do ecosystems change?										x	x	x	x	x	x
15.How does energy flow within an ecosystem?															
16.What are the responsibilities of humans towards ecosystems?															



Table 4

## Ecological Concepts

Questions from Science Framework	Ecological Concepts - Succession, Habitats, Interdependence and Population Dynamics	A Forest is Reborn After Fire	Processes of Recovery for Plants and Animals	Pollution from Animals	Interdependence of Plants and Animals	A Delicate Balance	Succession of our Forest	Population Explosion of Animals due to Human Tampering	Animal Symbiosis	The Role of Wildlife in the Scattering of seeds	Earth Systems	Geological Time	Solid Earth
<b><u>Living Things</u></b>													
1. What are the characteristics of life?													
2. How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?													
3. What are the relationships of living organisms, and how are living things classified?					x		x						
4. How do humans interact with other living things?						x		x					
<b><u>Cells, Genetics and Evolution</u></b>													
5. What are cells?													
6. What are cell components, structures and their functions?													
7. How do they grow?													
8. What is the biochemical basis of life and metabolism?	x	x											

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## Ecological Concepts

Questions from Science Framework	Ecological Concepts - Succession, Habitat, Interdependence and Population Dynamics	A Forest is Reborn After Fire	Process of Recovery for Plants and Animals	Pollution from Animals	Interdependence of Plants and Animals	A Delicate Balance	Succession of our Forest	Population Explosion of Animals due to Human Tampering	Animal Symbiosis	The Role Wildlife Plays in the Scattering of seeds	Earth's Systems	Geological Time	Solid Earth
9.How are the characteristics of living things passed on through generations?			x							x			
10.How does heredity determine the development of individual organisms?													
11.How has life changed and diversified through time?	x		x						x	x		x	
12.What processes and patterns characterize the evolution of life?										x		x	x
<u>Ecosystems</u>													
13.What are ecosystems and how do organisms interact in ecosystems?				x							x		
14.How do ecosystems change?													
15.How does energy flow within an ecosystem?											x		
16.What are the responsibilities of humans towards ecosystems?													

Table 5

## World Biomes

Questions from Science Framework	World Biomes - Tropical Forest	Dependency on the Trees, Animals, Plants and Soil	Animal Diversity	Slash and Burn	Temperate, Deciduous, and Coniferous Forests	A Year in each Type of Forest	Cycle or Changes that Occur Each Season	Deserts and Their Occupants	Desert Communities	Oceans, Reefs and Coastlands	Tidal Pools	Along our Coast	How Safe is the Water	Important Reefs
<b><u>Living Things</u></b>														
1.What are the characteristics of life?		x												
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?	x													
3.What are the relationships of living organisms, and how are living things classified?			x											
4.How do humans interact with other living things?														
<b><u>Cells, Genetics and Evolution</u></b>														
5.What are cells?														
6.What are cell components, structures and their functions?														
7.How do they grow?														
8.What is the biochemical basis of life and metabolism?														

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9.How are the characteristics of living things passed on through generations?														
10.How does heredity determine the development of individual organisms?														
11.How has life changed and diversified through time?			x											
12.What processes and patterns characterize the evolution of life?														
<u>Ecosystems</u>														
13.What are ecosystems and how do organisms interact in ecosystems?					x			x	x	x	x	x	x	x
14.How do ecosystems change?						x	x							
15.How does energy flow within an ecosystem?														
16.What are the responsibilities of humans towards ecosystems?				x									x	

Table 5

## World Biomes

Questions from Science Framework	World Biomes - Tundra and Polar Regions	Antarctica - plants and animals	Physical Characteristics of Plants and Animals	Survival Techniques of Plants and Animals	Changing Season of Plants and Animals	Grasslands, Meadows, and Prairies	Prairie Fires	Inhabitants of the Environment	Adaptation Through the Seasons	Physical Characteristics of Prairie Animals	Rivers, Ponds, Lakes, and Wetlands	Frogs and Their Adaptations to Ponds	Troubled Lakes	Dams and Rivers - Ecological Problems	Disappearance of Wetlands
<b><u>Living Things</u></b>															
1.What are the characteristics of life?			x							x					
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?			x							x					
3.What are the relationships of living organisms, and how are living things classified?															
4.How do humans interact with other living things?															
<b><u>Cells, Genetics and Evolution</u></b>															
5.What are cells?															
6.What are cell components, structures and their functions?															
7.How do they grow?															
8.What is the biochemical basis of life and metabolism?															

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9.How are the characteristics of living things passed on through generations?			x												
10.How does heredity determine the development of individual organisms?															
11.How has life changed and diversified through time?															
12.What processes and patterns characterize the evolution of life?															
<u>Ecosystems</u>															
13.What are ecosystems and how do organisms interact in ecosystems?	x	x			x	x	x	x	x		x	x			
14.How do ecosystems change?									x			x	x		
15.How does energy flow within an ecosystem?								x							
16.What are the responsibilities of humans towards ecosystems?							x						x	x	x

Table 6

Human Impact

Questions from Science Framework	Human Impact - Land Uses	Strip Mining	Urbanization	Urban Encroachment on Animals	Dumps	Waste	Land Management	Endangered Species, Biodiversity and Habitation	Fish	Endangered Plants - Extinction or Survival	Products from Plants	Biodiversity of Animals by Plant Biodiversity	Saving our Wildlife
<b><u>Living Things</u></b>													
1.What are the characteristics of life?													
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?													
3.What are the relationships of living organisms, and how are living things classified?													
4.How do humans interact with other living things?													
<b><u>Cells, Genetics and Evolution</u></b>													
5.What are cells?													
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9.How are the characteristics of living things passed on through generations?													
10.How does heredity determine the development of individual organisms?													
11.How has life changed and diversified through time?													
12.What processes and patterns characterize the evolution of life?													
<u>Ecosystems</u>													
13.What are ecosystems and how do organisms interact in ecosystems?	x							x				x	x
14.How do ecosystems change?													
15.How does energy flow within an ecosystem?							x						
16.What are the responsibilities of humans towards ecosystems?	x	x	x	x	x	x	x	x	x	x	x	x	x



Table 6

## Human Impact

Questions from Science Framework	Human Impact - Energy Production, Use and Conservation	Nuclear Energy	Renewable Energy Sources - Wind, Sun, Water and Manure	Dangers to our Environment	Oil Spills	Radiation	Illegal Waste Dumping	Birth Defects in Humans and Frogs	Pollution and the Effects on Humans and Plants	Human Impact - Deforestation	Tropical Forests	Deforestation, Effects on Animals	Deforestation, Effects on Plant Diversity	Long Term Effects or Problems of Deforestation
<b><u>Living Things</u></b>														
1.What are the characteristics of life?														
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?														
3.What are the relationships of living organisms, and how are living things classified?														
4.How do humans interact with other living things?	x							x	x	x				
<b><u>Cells, Genetics and Evolution</u></b>														
5.What are cells?								x						
6.What are cell components, structures and their functions?								x						
7.How do they grow?								x						
8.What is the biochemical basis of life and metabolism?								x						

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## Human Impact

Questions from Science Framework	Human Impact - Energy Production, Use and Conservation	Nuclear Energy	Renewable Energy Sources - Wind, Sun, Water and Manure	Dangers to our Environment	Oil Spills	Radiation	Illegal Waste Dumping	Birth Defects in Humans and Frogs	Pollution and the Effects on Humans and Plants	Human Impact - Deforestation	Tropical Forests	Deforestation, Effects on Animals	Deforestation, Effects on Plant Diversity	Long Term Effects or Problems of Deforestation
9.How are the characteristics of living things passed on through generations?								x	x	x				
10.How does heredity determine the development of individual organisms?								x						
11.How has life changed and diversified through time?									x	x				
12.What processes and patterns characterize the evolution of life?														
<u>Ecosystems</u>														
13.What are ecosystems and how do organisms interact in ecosystems?														
14.How do ecosystems change?														
15.How does energy flow within an ecosystem?														
16.What are the responsibilities of humans towards ecosystems?	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 6

## Human Impact

Questions from Science Framework	Human Impact - Global Warming, The Green House Effect and Acid Rain	Acid Rain	Effects on Plants and Animals	The Green House Effect	CFCs	Our Ozone Layer	Global Warming	Cancer Increases and Health	Increased Radiation from the Sun	Environmental Ethics and Health Issues	Effects of Pollution on Child Development	Increased Health Problems from Ozone Depletion	Increased Health Problems from Pollution	Attitudes Towards the Environment
<b><u>Living Things</u></b>														
1.What are the characteristics of life?														
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?														
3.What are the relationships of living organisms, and how are living things classified?														
4.How do humans interact with other living things?	x													
<b><u>Cells, Genetics and Evolution</u></b>														
5.What are cells?								x						
6.What are cell components, structures and their functions?								x						
7.How do they grow?														
8.What is the biochemical basis of life and metabolism?								x				x		

Table 6

## Human Impact

Questions from Science Framework	Human Impact - Global Warming, The Green House Effect and Acid Rain	Acid Rain	Effects on Plants and Animals	The Green House Effect	CFCs	Our Ozone Layer	Global Warming	Cancer Increases and Health	Increased Radiation from the Sun	Environmental Ethics and Health Issues	Effects of Pollution on Child Development	Increased Health Problems from Ozone Depletion	Increased Health Problems from Pollution	Attitudes Towards the Environment
9.How are the characteristics of living things passed on through generations?							x							
10.How does heredity determine the development of individual organisms?							x					x	x	
11.How has life changed and diversified through time?	x													
12.What processes and patterns characterize the evolution of life?														
<u>Ecosystems</u>														
13.What are ecosystems and how do organisms interact in ecosystems?														
14.How do ecosystems change?														
15.How does energy flow within an ecosystem?														
16.What are the responsibilities of humans towards ecosystems?		x	x	x	x	x	x	x	x	x	x	x	x	x

Table 7

## Environmental Ethics and Health Issues

Questions from Science Framework	Environmental Ethics and Health Issues - Effect of Pollution on Children's Development	Early Childhood Development	Ozone	Birth Defects	Increase in Health Problems	Increase in Childhood Asthma	Increased Cases of Skin Cancer	Increased Mutation in Nature				
<b><u>Living Things</u></b>												
1.What are the characteristics of life?	x											
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?		x		x			x					
3.What are the relationships of living organisms, and how are living things classified?												
4.How do humans interact with other living things?	x											
<b><u>Cells, Genetics and Evolution</u></b>												
5.What are cells?	x	x	x	x	x	x	x	x				
6.What are cell components, structures and their functions?		x		x		x	x					
7.How do they grow?		x		x		x						
8.What is the biochemical basis of life and metabolism?		x		x		x						

Table 7

## Environmental Ethics and Health Issues

Questions from Science Framework	Environmental Ethics and Health Issues - Effect of Pollution on Children's Development	Early Childhood Development	Ozone	Birth Defects	Increase in Health Problems	Increase in Childhood Asthma	Increased Cases of Skin Cancer	Increased Mutation in Nature				
9.How are the characteristics of living things passed on through generations?		x		x								
10.How does heredity determine the development of individual organisms?	x	x		x								
11.How has life changed and diversified through time?	x											
12.What processes and patterns characterize the evolution of life?												
<u>Ecosystems</u>												
13.What are ecosystems and how do organisms interact in ecosystems?												
14.How do ecosystems change?												
15.How does energy flow within an ecosystem?												
16.What are the responsibilities of humans towards ecosystems?	x	x	x	x	x	x	x	x				

Table 7

## Environmental Ethics and Health Issues

Questions from Science Framework	Environmental Ethics and Health Issues- Attitudes Towards the Environment	Exploitation	Science and Technology	Quick Fixes	Future of the Planet							
<b><u>Living Things</u></b>												
1.What are the characteristics of life?												
2.How do the structures of living things perform their functions, interact with each other and contribute to the maintenance and growth of the organism?												
3.What are the relationships of living organisms, and how are living things classified?												
4.How do humans interact with other living things?												
<b><u>Cells, Genetics and Evolution</u></b>												
5.What are cells?			x	x								
6.What are cell components, structures and their functions?												
7.How do they grow?												
8.What is the biochemical basis of life and metabolism?												

Table 7

## Environmental Ethics and Health Issues

Questions from Science Framework	Environmental Ethics and Health Issues- Attitudes Towards the Environment	Exploitation	Science and Technology	Quick Fixes	Future of the Planet							
9.How are the characteristics of living things passed on through generations?												
10.How does heredity determine the development of individual organisms?												
11.How has life changed and diversified through time?												
12.What processes and patterns characterize the evolution of life?					x							
<u>Ecosystems</u>												
13.What are ecosystems and how do organisms interact in ecosystems?	x											
14.How do ecosystems change?												
15.How does energy flow within an ecosystem?												
16.What are the responsibilities of humans towards ecosystems?	x	x	x	x	x							



## APPENDIX B

### Curriculum

## Lesson Design

Sample units which demonstrate the integration of the five topic areas have been provided. Each unit is designed to evoke awareness and develop conceptual knowledge that can be applied to a specific local issue. The student will learn how to use the scientific method in order to explore local problems. The student will show understanding of the concepts by providing written or oral knowledge, and ultimately the student will take steps to display goal and attainment skills, by developing possible solutions or action plans for the local issue. The units provide a hands-on, task-oriented section, allowing the student to gain knowledge through experience and experimentation.

Each unit lists the environmental topic areas that it covers, along with specific subtopic areas for each topic addressed. The local issues that this unit might be applicable to are also listed. After each unit, an appropriate student assessment section has been provided.

At the end of the units, Appendix C and D provide information on where to obtain resource and activity guides for the various sections.

The following sample units have been selected as representative units for local/global issue-based units. The units are designed to include group work along with project-oriented activities and individual components. This type of teaching format encourages cooperative instead of competitive learning, allowing for more student success. New vocabulary introduced in a lesson is defined in the teacher's background information to allow the teacher the ability to introduce these terms to the students as they are exposed to them.

The four sample units are listed below along with the local/global issue that that unit was designed to address.

Sand: The Drink of the Future?

This unit addresses the issue of water availability in Southern California. It also addresses our dependence upon water from Northern California and the Colorado River and how sufficient water may not be available in the future.

The Web of Life

This unit addresses the issue of human population growth and its effect on the food chain and on plant and animal habitats.

### Not Just a Wasteland

This unit addresses the issue of endangered plant species and how population growth is affecting the desert and its inhabitants.

### The O's Have It

This unit looks at how humans have impacted the ozone layer and the resulting problems that we are facing now and in the future.

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# Unit 1

## **Sand: The Drink of the Future?**

**Subject:** Environmental Science, Science

**Grade:** 11th-12th grade

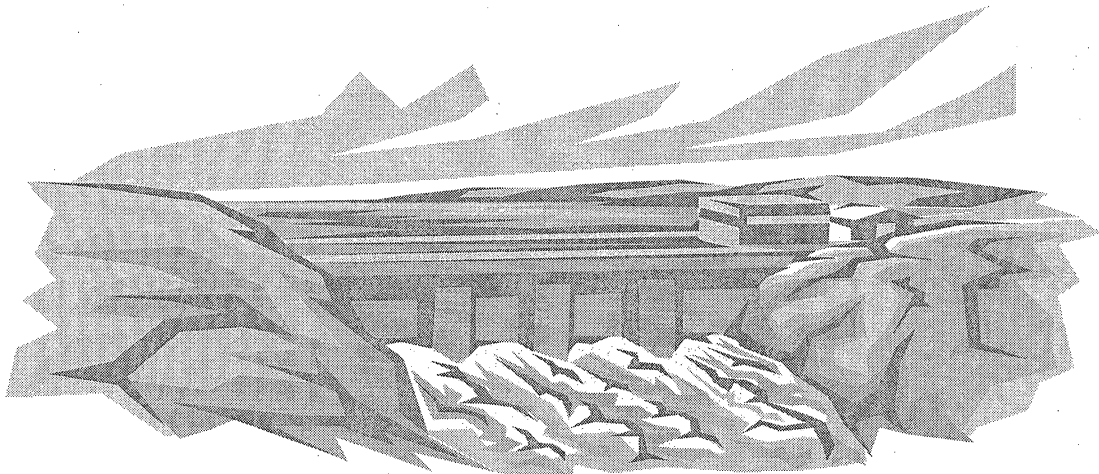
**Topic:** Natural Resources

**Subtopic:** Conservation of Groundwater and Drinking Water

**Topic:** Human Impact

**Subtopic:** Population Growth Effects on Pollution

**Unit Issue:** This unit addresses the issue of water availability in Southern California. It focuses on the concerns created by the growing population of Southern California and its growing need for water transportation from Northern California.



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# Sand...

## The Drink of the Future?

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### Lesson 1

**Lesson Summary:** Students will identify where their drinking water comes from and will be introduced to how the California Water Project has impacted Southern California.

**General Goal:** To introduce students to the history of the California Water Project and its significance to the people of Southern California.

**Duration:** 3 or 4 class periods lasting 55 minutes long.

**Learning Objectives:**

Upon completion of this lesson, students will be able to:

1. Explain what the California Water Project is,
2. Identify where the majority of water used by Southern California originates,
3. Recognize the various steps necessary for transporting water from Northern California to Southern California, and
4. Identify some of the ways that water is conserved in each student's home.

---

# Teacher Background

The following background information has been provided in order to help the teacher answer student questions. The various articles each pertain to the history of water use in Southern California. The information has been collected from a variety of public domain Internet sites, which are identified at the end of each article.

## **Sacramento--San Joaquin Delta and California Aqueduct and California Aqueduct Sacramento-San Joaquin Delta**

The Sacramento Delta is a marsh located on the north eastern part of the San Joaquin Valley. It gets most of its water from the Oroville Dam on Feather River and the Sacramento River. All 42 rivers that runs into the delta have dams build on them for collection of water and prevention of flooding. It also drains millions of gallons of water from farmland. The delta is an environmentally sensitive resource but, now, the modern delta is not a natural system anymore; it has been shaped by humans to conserve more water than it naturally did. This transformation began in the 1850s by cheap labor, mostly Chinese workmen.

### **Annual inflow**

Between 1922 to 1950 the annual delta inflow was 19.8 million acre-feet of water. Mostly from rainy seasons, runoff and snow melt flowing from the mountains; which is more water than the Colorado River carries. In 1969, 43.3

million acre-feet of freshwater went into the delta; a very wet year. Eight years later in 1977 5.9 million acre-feet went into the delta during a severe drought. The whole state of California depends on the delta for 40% of its drinking water and too many industries rely on it for water, which made it harder for the state to supply.

## **Water Quality**

The quality of the water in the delta is the result of the daily tug of war between the freshwater in the delta and the incoming tidal surges of saltwater. In the 1940s the Reber Plan was concocted to keep saltwater out of the delta. The Reber Plan was conceived by drama teacher and actor John Reber. It was an idea of building giant barriers across the San Francisco Bay. It was a good idea at first but later after careful examination it would have caused an ecological disaster.

## **California Aqueduct**

The battle between the northern part and southern part of California is an on going process. The Department of Water Resources solved that problem with the State Water Project: building the California Aqueduct, also know as the Sacramento Aqueduct. This was the product of two men, Governor Edmund G. "Pat" Brown and A. D. Edmunston, the state engineer.

The Sacramento Aqueduct flows 73 miles south of the delta to the San Lugs Reservoir (the 2nd major storage facility) storing 2 million acre-feet of water. Flowing through the San Joaquin Valley it goes to San Lugs Obispo in the Santa Barbara counties. It then runs 2,000 feet to the Tehachapi; East Branch and West Branch. The West Branch goes to the Castaic Lake, north of San Fernando Valley. The East Branch goes to the Los Angeles basin and then extending 140 miles to the terminal reservoir (Lake Perris).

## **Water from the Colorado River**

The Colorado River supplies water for seven states and Mexico. The Colorado River is a major river of the southwestern U.S. Created by rain and melting snow in the Rocky Mountains. The Colorado River carries water west across the dessert and it ends at the end of Baja. The Colorado River is 1,400 miles long. The Colorado River is one of the most important water source of the southwestern of the U.S. because 25,000,000 people in both the U.S. and Mexico depend on it.

Colorado River Aqueduct started construction in 1933 and was finished in



1941. The Aqueduct has 5 pumping plants to pump the water. It starts at Lake Havasu and it ends in Lake Mathews. Its width is 16 feet in diameter and is 242 miles long. The Colorado River Aqueduct carries about 1.212 million acre- feet of water. It provides water for both Los Angeles and San Diego.

(Post the following on the board for student information)

### **Facts**

- California Aqueduct is 444-miles long.
- At the Tehachapi Mountains, the aqueduct could separate into two branches, the West, transporting water to Castaic Lake, and the East skirting the Los Angeles basin and extending another 140 miles before terminating at Lake Perris near Riverside.
- Roughly 75 percent of the natural runoff occurs in the northern part of California, while about 75 percent of the net water demand is in the semi-arid central and southern part of California.
- An acre-foot equals 326,000 gallons of water. All 42 rivers that run into the delta have dams built on them for collection of water and prevention of flooding.
- California's main industry agriculture has at least 60% of the available water diverted to them each year. Agriculture accounts for over \$300 million dollars per year.
- Percolating grounds are where water is put back into the ground and cleaned using Mother Nature. We then pump the water back out of the ground to be treated before we drink it.

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# Lesson 1

## Activities

### Materials

For each student copy the following materials:

1. California Water Quiz.
2. Map 1
3. Graphic Organizer.
4. Fact information from teacher background. Teacher should either make handout of that information or post on the board.
5. California Water Information and any information the teacher wants to provide from the teacher background.

### Focusing

1. Pass out the California Water Quiz and have the students complete it as best they can. This will get the class focused on the subject of water, and start the students thinking about water in California.
2. Discuss the students' answers to the California Water Quiz during class. Have them explain why they chose each answer.

### Finding Out

1. Give students the "California Water Information Sheet" handout and "Map 1;" then give them the Graphic Organizer. Using the handout, have them complete the graphic organizer.
2. Have students identify problems that could happen to the water supply, as it travels from Northern California to their homes.

Examples might be: Water is diverted and used by others. Contamination occurs resulting in the water not being fit for human consumption. Water evaporates. The aqueduct breaks. Etc.

## **Bridging**

1. Discuss with the students what Southern California would probably be like if we did not import any water.
2. Have the students write a story about an alternative history of California, whereby the State Water Project had never been built.
3. Discuss with the students how their understanding of how water availability has changed.
4. Have the students identify ways in which they waste water and could better conserve water in their homes.

## **Assessment**

1. Each student will be able to demonstrate an understanding of how water gets to his or her home from Northern California, through the use of two different methods to display this knowledge (i.e., essay, oral communication, poster, model, etc.)
2. Each student will be able to display problem-solving skills by identifying three different ways that people conserve water.

Name \_\_\_\_\_ Date \_\_\_\_\_ Period \_\_\_\_\_

## California Water Quiz

(circle correct responses)

1. Most of Southern California's water comes from Northern California.  
True / False
2. Agriculture is the largest source of employment in California.  
True / False
3. The Central Valley Project was originally started to transport agricultural water to the Central Valley.  
True / False
4. Each year we use more groundwater than is returned to the ground.  
True / False
5. Hydroelectric power accounts for \_\_\_\_ of the state's energy each year.  
10%                      20%                      30%
6. About 75% of California's water supply originates north of Sacramento, while \_\_\_\_ of its water demand occurs south of this point.  
70%                      75%                      80%
7. Water storage and transportation systems move about \_\_\_\_ of the state's total water requirements.  
60%                      65%                      70%

8. About \_\_\_\_\_ of the watershed in California is pumped from underground.

35%

40%

45%

9. Approximately \_\_\_\_\_ of Southern California water is used by agriculture.

20%

30%

40%

10. Name five benefits of water development:

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11. Today, \_\_\_\_\_ acre-feet of water are delivered to the Central Valley.

7 million

8 million

9 million

12. Where did 40% of California's water runoff converge, before going to the ocean? \_\_\_\_\_

Answer Sheet: **California Water Quiz**

1. True
2. True
3. True
4. True
5. 30%
6. 75%
7. 60%
8. 35%
9. 30%
10. Transport water for: Agriculture, Parks, Boating,  
Swimming Areas, Recreation Areas
11. 8 million
12. Delta area in San Francisco

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# California Water Information Sheet

## Water in California

The history of water development and distribution in California is a story of supply and demand. California is unique, due to the magnitude and diversity of its water development by local, private, state and federal agencies. Today, California's citizens have an adequate supply of water in most years for public, agricultural and industrial use because of the foresight and planning of the state's early water managers.

The benefits Californians receive from this water supply include drinking water, irrigation water, flood control, water quality control, fish and wildlife support, recreational opportunities, improvement of navigable waterways, and the generation of hydroelectric power.

## Water Use and Benefits

California uses its water for a multitude of beneficial purposes.

Agriculture, California's biggest industry, uses about 85% of the state's water, principally for irrigation in this semi-arid state. In return, California's agricultural production leads the nation with about \$15 billion worth of crops. Additionally, agriculture is a large source of employment in the state.

Water projects also help to repel salt water intrusion into areas bordered by irrigable land such as the Sacramento-San Joaquin River Delta. Flood control projects have prevented billions of dollars in damage and saved many lives.

Generation of hydroelectric power provides about 20% of the state's energy each year. About 50 million barrels of oil would be needed to generate the 30 billion kilowatt hours of electric energy produced by California's hydroelectric plants each year. Other benefits of water development include reservoir recreation which includes swimming, boating, camping and fishing.

## Distribution

About 75% of California's available water originates north of Sacramento, while about 75% of its water requirements occur south of this point. In addition, runoff from northern rainfall and snowmelt occurs in the winter and spring months, while the greatest demand is during the summer and fall. This problem of natural water distribution and timing has been solved somewhat by water storage and transportation systems. These systems, which move about 60% of the state's total water requirements, are used to make water available where and when it is needed. Included in these systems are the federal Central Valley Project, the State Water Project and projects of regional and local water agencies. About 40% of the water used in California is pumped from underground. Each year we use more ground water than goes back into the ground.

While our basic water supplies may be supplemented by technological improvements in desalinization and wastewater reclamation, and demands reduced by conservation, the development of surface and ground water resources continues to be the major source of California's water supply.

## The State Water Project

The State of California's first water resources plan was released in 1957. In 1960 California's voters approved financing for construction of the initial state water development projects. Not yet completed, the State Water Project (SWP) consists of large dams, reservoirs and the California Aqueduct. The project begins at Oroville Dam on the Feather River in Northern California and ends at Lake Perris in Southern California.

With contracts to deliver more than four million acre-feet annually, the SWP presently provides about two and one-half million acre-feet annually. In order to meet contractual commitments, additional water projects will be required. Southern California and the San Joaquin Valley are the two largest users of SWP water.

Approximately 30% of SWP water is used by agriculture and the remainder used by domestic and industrial users. Urban and domestic use is expected to increase.



## The Central Valley Project

Before the development of its water facilities, California was a land subject to devastating droughts and floods. Its early water planners sought orderly ways to conserve and develop its water resources.

Construction of the Central Valley Project (CVP) was started by the federal government during the Depression. The project stores and transports surplus water of the Sacramento and San Joaquin Rivers for use primarily in the Central Valley of California for irrigation. Additional projects were then built and today the CVP delivers about 8 million acre-feet of water to the Central Valley. The federal CVP was financed by appropriations from Congress and portions are repaid by water and power users. In the future, local project sponsors must agree to cost sharing arrangements to receive federal funding.

The CVP facilities were built by the U. S. Bureau of Reclamation and the U.S. Army Corps of Engineers and today are managed by the Bureau of Reclamation. The CVP consists of a number of major dams and canals beginning at Shasta Dam on the Sacramento River and ending on the Kern River near Bakersfield.

## San Francisco Bay and the Sacramento-San Joaquin River Delta

About 40 percent of California's runoff historically converged into a low point in the state's geography - the Sacramento-San Joaquin River Delta and the San Francisco Bay. Today, water diversions to other parts of California have reduced this runoff as the Delta has become the heart of the state's water conveyance system and an area of controversy in water decisions.

The Delta, originally a natural marshland, was developed for farming around the turn of the century. Today it contains about 550,000 acres of rich farmland and 700 miles of rivers and sloughs. Salt water from San Francisco Bay is repelled from the fresh water Delta by releases from upstream dams. In 1986, the state and federal governments reached a historic agreement on how they would coordinate the operation of the State Water Project and Central Valley Project to best utilize the water from both projects and protect the water quality of the Bay and Delta.

## Local Development

Nearly 600 special purpose local governments in California provide water to the areas they serve through local development projects and through imported supplies. Many local water districts provide domestic and industrial water and others serve agricultural needs. A local water agency is usually formed by a vote of the community and governed by elected directors. These local agencies may sell bonds to finance new projects and improvements, if authorized by an election, and must operate on a nonprofit basis.

Since the early 1900's, water import programs have made possible the development of the San Francisco Bay area, Los Angeles and other Southern California cities and agricultural areas statewide. Local districts have also worked with utilities to construct projects providing water and power.

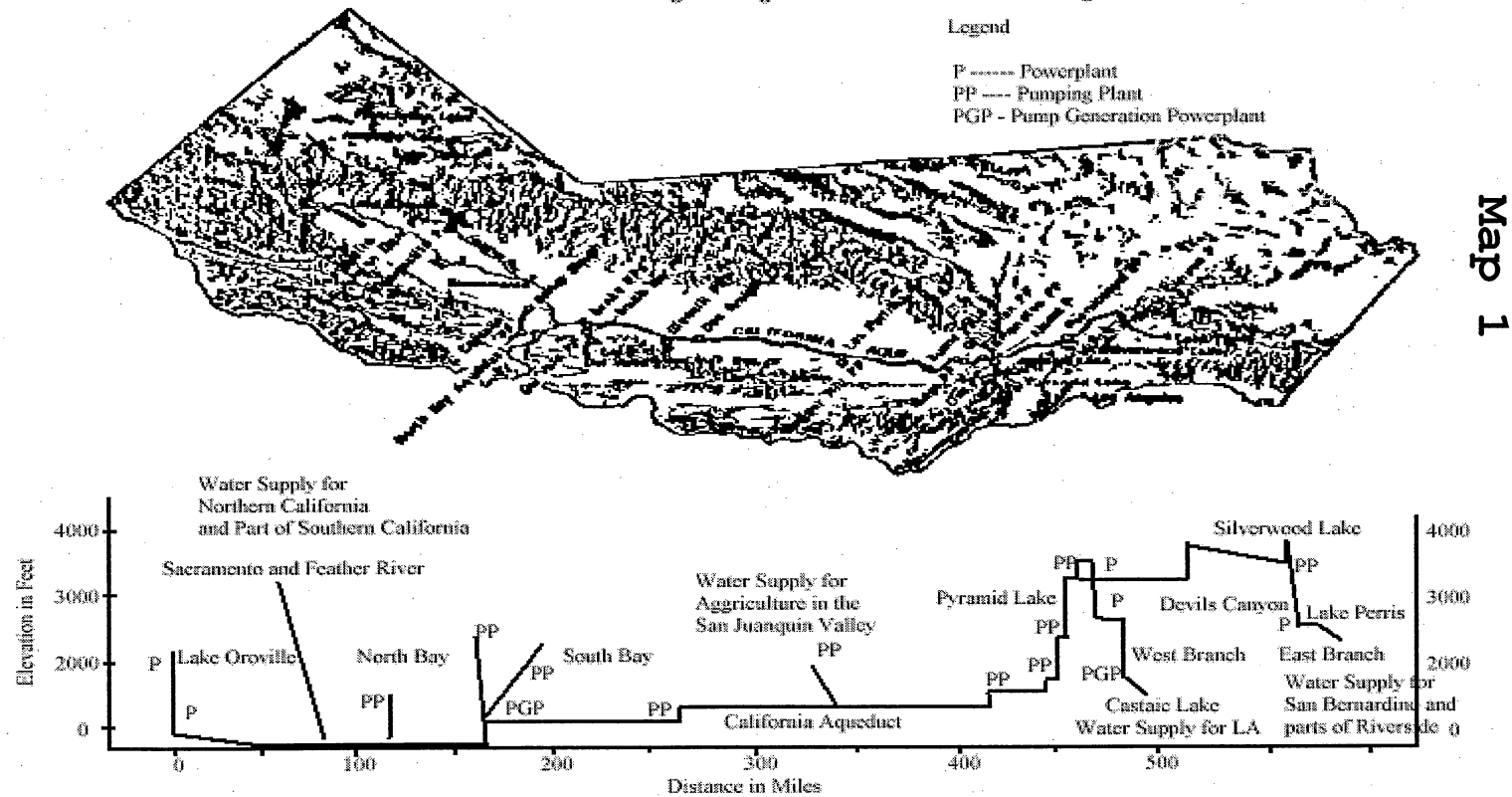
Major local water projects in the north include the Hetch Hetchy Aqueduct, transporting Tuolumne River water to San Francisco and the peninsula. The Pardee and Camanche Reservoirs, built by the East Bay Municipal Utility District, supply the East Bay's city service area.

After Congress approved construction of Hoover Dam in 1928, a group of Southern California cities, including Los Angeles, formed Metropolitan Water District of Southern California (MWD) and built the Colorado River Aqueduct which began delivering water in 1941. The All-American Canal was completed in 1940 to divert water from the Colorado River to agricultural land in the Imperial Valley. Although federal funding was needed for the canal, the Imperial Irrigation District built and maintains the distribution system and also operates and maintains the canal. The Coachella Valley County Water District helped to finance the Coachella Branch of the All-American Canal and built and maintains the distribution system.

## Wild and Scenic Rivers

In 1972, the state Wild and Scenic Rivers Act mostly prohibited the construction of dams or diversion structures on the entire Smith River, parts of the Klamath, Trinity, Van Duzen, Scott, Eel, Salmon, Feather, and American Rivers. In 1980 the Secretary of the Interior added further protection to these rivers when he placed them under the Federal Wild and Scenic River System. The Tuolumne River was added to the federal system in 1984. The U.S. Supreme Court in 1985 upheld the action of the Interior Secretary in giving rivers federal protection.

## *Location and Profile of State Water Project Facilities*



The elevation in feet indicates the height of a specific area that water must be pumped up in order for the water to reach its final destination on the other side. Energy is gained at these areas by using the force of the water traveling downhill to turn turbines that create useable energy.

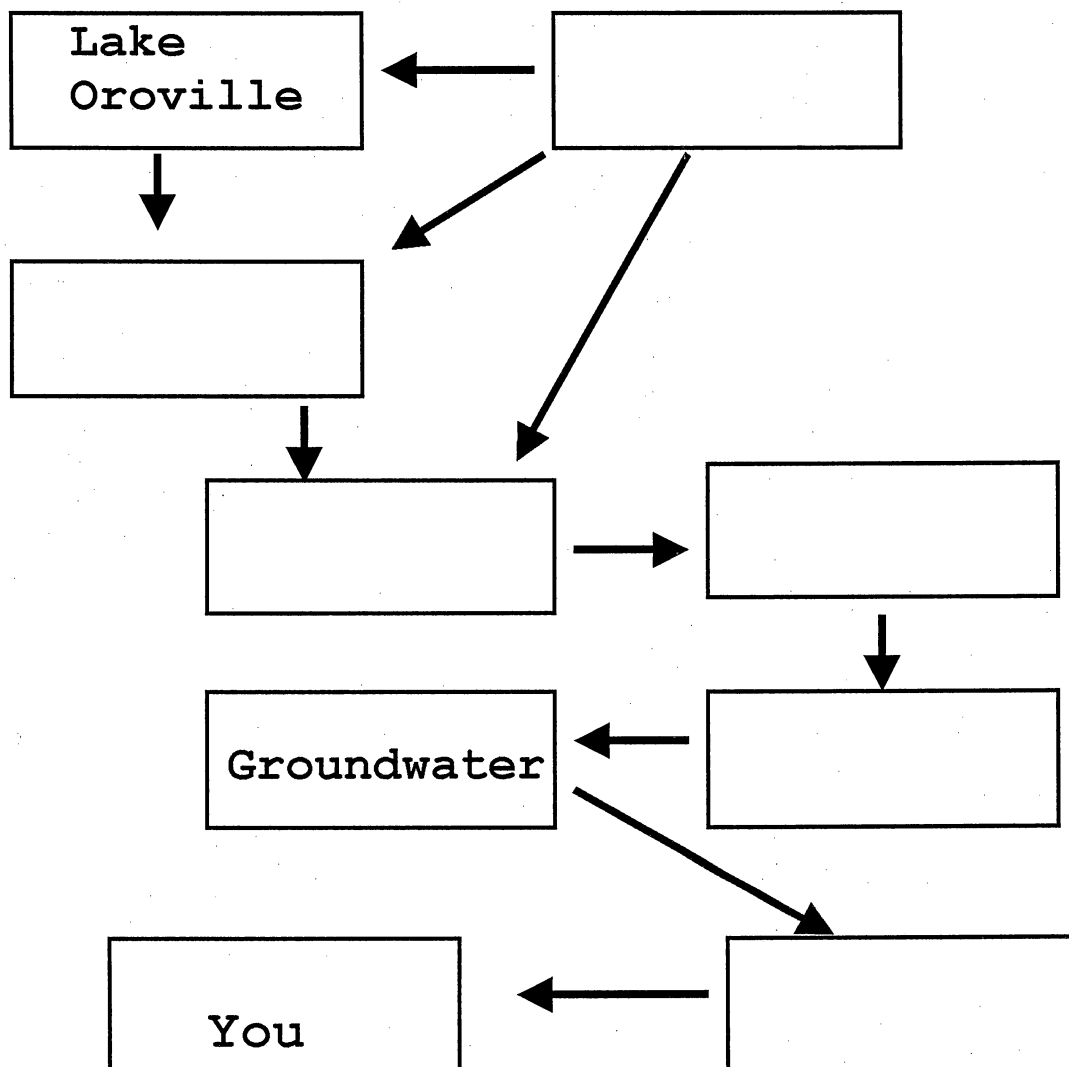
# Graphic Organizer

*"How drinking water gets to my house"*

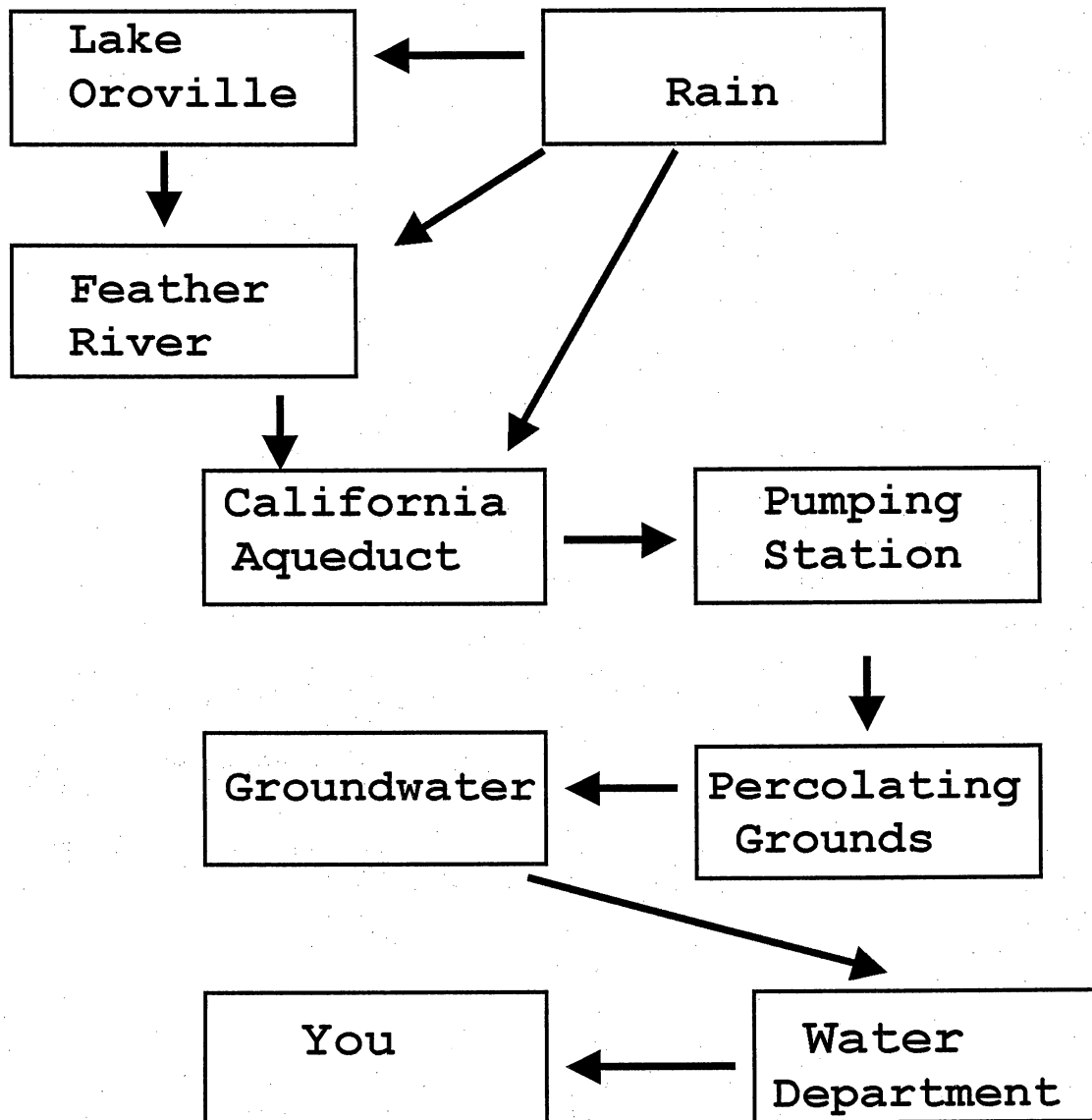
Organize the following terms into the correct order in the graphic organizer. These are the steps that water goes through to get from Lake Oroville to you.

California Aqueduct  
Feather River  
Pumping Station

Rain  
Percolating grounds  
Water Department



Answer Sheet: **Graphic Organizer**



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# Sand. The Drink of the Future?

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## Lesson 2

**Lesson Summary:** Students will identify how much drinking water is on planet earth. They will then determine what part of this water is used for human consumption, and what part is used for agriculture.

**General Goal:** To introduce students to the problem of the limited water resources on the planet and the increasing demand for that water.

**Duration:** 4 or 5 class periods lasting 55 minutes long.

### Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Explain how much drinking water is on the earth.
2. Identify how much water is used for human consumption and agriculture in California.
3. Recognize the various demands made upon the available water resources of California.

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# Teacher Background

The following background information has been provided in order to help the teacher answer student questions:

California depended heavily on the existing water within the state to provide for its inhabitants. As the population increased in areas that little water was available it became necessary to transport water to those areas from areas where water was more readily available. The American Canal was created in order to bring water from the Colorado River in order to provide Southern California with its needed water and relieve the stress that had been placed on the rest of the state as the population increased.

As the human population continued to grow and agriculture began to grow in order to support the peoples need, the demand for water increased. This was one of the driving forces behind the California Water Project. However, the great population explosion in Southern California, a rather arid region, has caused a greater demands for water then California alone can provide.

- Water covers 71% of the earth; however, living things can not consume the majority of this water.
- The availability of **usable** water on our planet is one of the main limiting factors for life on this planet.
- If all the available water was put together, it would be 8.4 million liters per person. This is about .00003 % of the total water on earth.
- Even though water may seem to be very abundant, geography, climate, and weather affect water distribution. Agricultural, industrial and domestic use also affect availability.
- The amount of water available also needs to take into account water frozen into ice at the north and south poles, water contaminated by pollution or

sewage, and water that is too far underground for us to reach.

The following information is necessary for student to complete Finding Out, Part 2:

- An average human consumes 43,788 gal/year.
- The population of California was 32.5 million as of Jan. 1, 1997.
- An acre-foot of water = 326,000 gallons.
- California receives 34 million acre-feet of water each year.
- Agriculture uses 60% of the available water that is used in California.
- 29.8 million acre-feet of water is currently used in California each year.



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# Lesson 2

## Activities

### Materials

For each student, copy the following materials:

1. Water Trivia Quiz.
2. Copy of lab sheet adapted from Project WET.
3. California Water handout from lesson 1.

For each group of four/five students, provide the following materials:

4. Construction paper in the colors of white, blue, and red, ruler, scissors and marker.
5. 1000-ml beaker, a 100-ml graduated cylinder, a 10-ml graduated cylinder, 50-ml beaker, and a 50-ml, 10-ml and 1-ml pipette.

### Focusing

1. How much water do they think they use a day?
2. Have the students take the Water Trivia Quiz. This will help the students recognize the amount of water necessary to make many of the items they use everyday.
3. Discuss the answers to the quiz in class. Were the students surprised at how much water it took to make the things they use everyday? Discuss why they were surprised.

### Finding Out

1. Have the students do a "Drop in the Bucket" Project WET lesson using the lab report form provided.
2. Have the students make a chart, which shows how much water California has each year. Out of that available water, have them show how much is for human consumption, how much is used for agriculture, how much is used for other things, and how much is left over. What might be some uses for the rest of the water?

3. Have the students answer the following questions.  
What will happen to the use of water in the future?  
Why does agriculture use 60% of the water? Will  
humans or agriculture consume more water as population  
increases? How will these increases of water  
consumption impact California Agriculture?

### **Bridging**

1. Have the students in groups design a game board about California Water.
2. Have the students design the game so that it represents some of the facts that they have learned so far. Make sure they don't forget to write out the directions. Have the various groups switch games to evaluate how well the game can be played.

### **Assessment**

1. The student will be able to identify the amount of useable water on earth.
2. The student will be able to transfer some of the knowledge that has been learned thus far, by producing a playable water game. This will be determined by having other class members play the game.

## Water Trivia

1. How much water does it take to make four new tires?
2. How many households in the U.S. use private wells for their water supply?
3. How much water per year do we get from the Colorado River?
4. How much water per year does the federal Central Valley Project deliver?
5. How long can a person live without water?
6. How long can a person live without food?
7. How much water must a person consume per day to maintain health?
8. How much water do state experts estimate we could be short by the year 2010?
9. How much water can California reservoirs store?
10. How much water does brushing your teeth use?
11. How much water is used in the average five-minute shower?
12. How much water is used to flush a toilet?
13. How much water is delivered by the state water project to Southern California each year?
14. How much fresh water flows from the Delta into the ocean?
15. How much groundwater do we use?
16. How much water does an individual in Southern California use daily?
17. At what temperature (Celsius) does water freeze?
18. At what temperature (Celsius) does water boil?
19. How much water is in one cubic foot?
20. How much of the earth's water supply is held in lakes and streams?

## Answer Sheet: **Water Trivia**

1. 2,072 gallons
2. 17,000,000 households
3. 4.4 million acre-feet per year
4. 7 million acre-feet per year
5. Approximately one week
6. More than a month
7. 2 1/2 quarts from all sources
8. 4 million acre-feet per year
9. 34 million acre-feet per year
10. 2 gallons
11. 25-50 gallons
12. 2-7 gallons
13. 2.4 million acre-feet per year
14. 16 million acre-feet per year
15. 16 million acre-feet per year
16. 123 gallons
17. 0 degrees C
18. 100 degrees C
19. 7.84 gallons
20. 0.01%

*Note: An acre-foot of water = 326,000 gallons.*

## Lab Report Form

### A Drop In The Bucket

**Purpose:** To estimate and then calculate the percent of available fresh water on Earth.

**Objective:** To explain why fresh water is a limited resource.

**Materials:** Each group of four students needs construction paper, (white, blue, and red), ruler, scissors, marker, a 1000-ml beaker, a 100-ml graduated cylinder, a 10-ml graduated cylinder, 50-ml beaker, and a 50-ml, 10-ml and 1-ml pipette.

**Procedure:**

1. Gather the necessary materials.
2. Estimate how much of the 70% of water on earth is useable by doing the following:
  - A. On a piece of white paper draw a large circle.
  - B. Use two pieces of construction paper that are the same size. One of blue construction paper to represent the usable water on earth and the other of red construction paper to represent the non-usable water on earth.
  - C. Tear/cut each color into 100 pieces.
  - D. Now place the red and blue pieces into the circle that you drew. You do not have to use all of the pieces. Use only the number of red and blue pieces that represent the non-useable and useable water on the planet. Set off to the side.
  - E. Construct a hypothesis for the available drinking water on the planet from the estimate that your group just made.

## Lab Report Form

### A Drop In The Bucket

3. You will perform the following experiment to determine how much usable water there is on earth.
- A. Use a liter container to represent all available water on earth. Fill it with water to the 1000ml mark.
  - B. Measure out 3% of this water. Place this amount of water into the 100ml-graduated cylinder. This is the amount of fresh water on earth.

Amount of Water \_\_\_\_\_ (units)

- C. Out of the amount of fresh water placed in the graduated cylinder, 80% of this water is frozen at the poles. Remove 20% of the water to represent the non-frozen fresh water and place it in the 10ml-graduated cylinder.

Amount of Water \_\_\_\_\_ (units)

- D. .05% of the non-frozen fresh water is left that can be accessed and used for drinking water. Place this amount of water in the 50ml beaker.

Amount of Water \_\_\_\_\_ (units)

- 4. The actual amount of water available for our use is 1.68 billion liters.
- 5. Using this number to calculate how many liters of water there are on earth using the information you already have.

#### Conclusion:

- 1. How accurate was your hypothesis?
- 2. Is the amount of available water going to increase or decrease in the future? Why or why not?
- 3. Summarize what you learned about water today.

---

# Sand.

## The Drink of the Future?

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### Lesson 3

**Lesson Summary:** Students will identify how much water they use each day, each week, and each year. Finally they will choose a river or lake from the provided list in order to research its history in supplying California with water.

**General Goal:** To introduce students to the amount of water that a person uses each day, each week, and each year. To use a variety of research techniques in order to find information on lakes and rivers.

**Duration:** 5 or 6 class periods lasting 55 minutes long.

#### Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Explain how much water they use each day, a week and a year.
2. Recognize the various demands made upon the available water by Southern California.
3. Determine how much water must be transported in order to meet the demand of Southern California's water needs.
4. Choose a river or lake from the California Rivers and Lakes List in order to research the history of that river or lake and its role in supplying California with water.

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# Teacher Background

The students will need access to a variety of research tools. Access to the Internet, public library or school library will need to be arranged in order to research history of the rivers and lakes in California.



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# Lesson 3

## Activities

### Materials

1. One calculator per student.
2. One copy of the "Fact Sheet" for each student.
3. One of the "California Rivers and Lakes List."

### Focusing

Have the students write down their answer on a piece of paper for the following questions:

1. How much water they think they use every day? Every week? Every year?

### Finding Out

1. Have the students calculate how much water they use in a day, a week, and a year by using the information on the Fact Sheet.
2. Have the students determine how much water the Southern California population uses each day, if we estimate that there are 18 million people in the Southern California area.

### Bridging

1. Have each students select a lake or a river from the California Rivers and Lakes List.
2. Have each student research his/her river or lake and gather information concerning its contribution to water transportation in California.
3. The students will use the public library, a university library or the Internet in order to find information.
4. Have the students present the history of his/her river or lake to the class.

## **Assessment**

1. The student will be able to identify the amount of water they use each day, each week, and each year.
2. The students will be able to present a historical account of a river or lake and its role in the transportation and delivery of water in California.

## California Rivers and Lakes List

- |                       |                               |
|-----------------------|-------------------------------|
| 1. American River     | 17. Merced River              |
| 2. Auburn Dam         | 18. Owens River               |
| 3. Calaveras River    | 19. Pit River                 |
| 4. Castaic Lake       | 20. Pyramid Lake              |
| 5. Chowchilla River   | 21. Rubicon River             |
| 6. Clair Engle Lake   | 22. Sacramento River          |
| 7. Cosumnes River     | 23. San Gabriel River         |
| 8. Feather River      | 24. San Joaquin River         |
| 9. Kern River         | 25. Santa Ana River           |
| 10. Kings River       | 26. Shasta Lake               |
| 11. Lake Mathews      | 27. Silverwood Lake           |
| 12. Lake Orville      | 28. Stanislaus River          |
| 13. Lake Perris       | 29. Trinity River             |
| 14. Los Angeles River | 30. Tuolumne River            |
| 15. Mojave River      | 31. Whiskey Town<br>Reservoir |
| 16. McCloud River     | 32. Yuba River                |

## FACT SHEET

Here are a few interesting facts and quotes that can be read to your students when a rest period is needed.

According to . . . Zero Population Growth

- The earth is made up of 79% water.
- In 24 hours, the average urban American:
  - Consumes 150 gallons of water
  - Produces 120 gallons of sewage
  - Consumes 3.3 pounds of food
  - Produces 3.4 pounds of garbage
  - Consumes 15 pounds of fossil fuels
  - Produces 1.3 pounds of pollutants

# **Sand. The Drink of the Future?**

## **Lesson 4**

**Lesson Summary:** Working in small groups and using collaborative critical thinking skills, students will be able to weigh the positive and negative impacts of the State Water Project (SWP) on specific areas of the State's environment and will advise the class as to the relative value of the SWP.

**General Goal:** To introduce students to the problem of the limited water resources on the planet and the issues surrounding the transportation and usage of this water in California.

**Duration:** 5 or 6 class periods lasting 55 minutes long.

### **Learning Objectives**

Upon completion of this lesson, students will be able to:

1. Identify some of the positive and negative impacts of the State Water Project on the state's population trends.
2. Identify effects that population growth has on local areas.
3. Explain how population growth in Southern California may affect the State Water Project.

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# Teacher Background

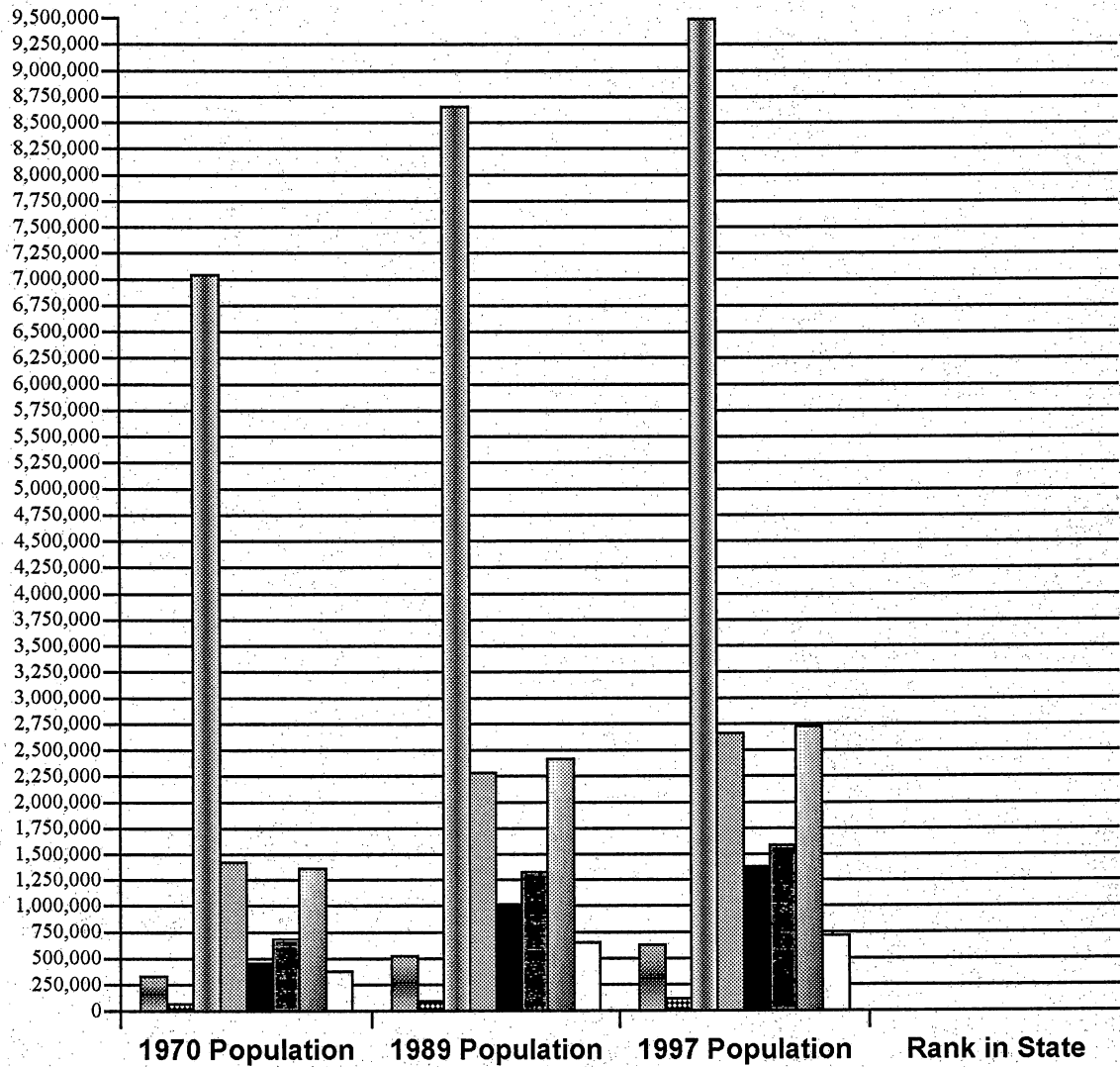
The following information has been supplied in order to help the teacher answer student questions more efficiently. The chart at the end is also needed by the students in order to do some of the lesson activities.

Throughout its history, California has experienced a series of population booms. By 1986, 11.2% of the U.S. population lived in California. Because of its inviting climate and prospect of a variety of jobs many people from around the world have made California their home. California has grown steadily, and the areas leading this growth have primarily been in Southern California, especially San Diego, San Bernardino, Riverside, and Los Angeles counties. This pattern of growth is expected to continue well into the future, as is illustrated by the regional population growth chart on the next page.

This growth has placed tremendous demands upon maintaining an adequate water supply. Much of this growth would not have occurred without new facilities from adequate water supply. As the demand for water has increased in Southern California, the amount of water necessary from other parts of California and Colorado have increased. Along with the population growth, the state's economy also grew, creating more jobs and more pollution.

With the increase in population there has also been an increase in water and air pollution, an increased rate of habitat destruction, the production of more sewage, and the need for creating larger landfill sites.

### Regional Population Growth Chart



	1970 Population	1989 Population	1997 Population	Rank in State
Kern	330,234	526,600	628,200	14
Kings	66,717	96,000	118,200	34
Los Angeles	7,041,980	8,650,300	9,488,200	1
Orange	1,421,233	2,280,400	2,659,300	3
Riverside	456,916	1,014,800	1,380,000	6
San Bernardino	682,233	1,324,600	1,587,400	5
San Diego	1,357,854	2,418,200	2,724,400	2
Ventura	378,497	653,600	716,800	12

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# Lesson 4

## Activities

### Materials

1. Copy of "Regional Population Growth Chart".
2. One Calculator
3. Graph paper

### Focusing

1. Have the students answer the following questions looking at the Regional Population Growth Chart.
  - A. Which county had the largest increase in numbers of people from 1970 to 1989, and then from 1989 to 1997?
  - B. Were the counties the same in number A? Why or why not?
  - C. Do you live in one of these counties? Were you born there or did you move there?

### Finding Out

1. Have the students predict how many people will be living in these counties in the year 2010. They can do this by plotting the data for each county on a graph and then extrapolating to the year 2010.
2. What impact will the increased population do to our water needs? How will we meet these water needs?
3. Have the students determine how much more water we will need by the year 2010 at the present level.
4. They can do this by taking the yearly amount of water for southern California given in lesson 2 and divide this by the current Southern Californian population.
5. They can then take the per person amount of water and times it by the new predicted Southern California population for the year 2010.



## **Bridging**

1. Not only will water use increase as our population increases but the amount of sewage, garbage and pollution will also increase.
2. Using the "Fact Sheet" from lesson 3 have the student calculate out the amount of sewage, garbage and pollution produced for the county for the years shown on the "Regional Population Growth Chart".
3. They can do this by taking the average amount of sewage and times it by the population of that time period.
4. Have the students use the figure for the year 2010 that was extrapolated and determine how much each area will increase.
5. Have the students design a board which demonstrates some of the possible outcomes as population increases in Southern California. Graphs and charts with explanations is one effective way convey the information. Title the board "Population Growth Board."

## **Assessment**

1. The students will be able to show population trends in Southern California.
2. The students will be able to identify problems that could occur due to population growth in Southern California.
3. The students will demonstrate their knowledge by constructing a "population growth board."

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# Unit 2

## The Web of Life.

**Subject** Environmental Science, Science

**Grade** 11th-12th grade

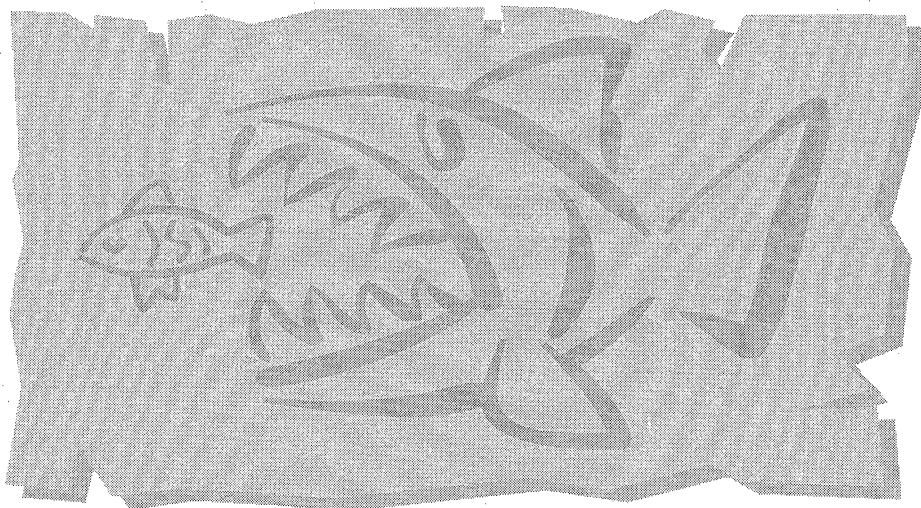
**Topic** Ecological Concepts

**Subtopic** Food Webs and Energy Flow

**Topic** Human Impact

**Subtopic** Population Growth

**Unit Issue** This unit addresses the issue of human population growth and its effect on the food chain and on plant and animal habitats.



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# The Web of Life

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## Lesson 1

**Lesson Summary** The students will identify what components are in a food chain. The students will then demonstrate how the extinction of a species affects the food chain.

**General Goal** To introduce students to what the components of a food chain are and how species extinction can affect it.

**Duration** 3 or 4 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Identify the different animals found in the community and then identify what they eat.
2. Recognize the various steps in a food chain.
3. Identify the different parts of the food chain and identify them as producers, primary consumers, secondary consumers, or decomposers.
4. Explain how a change in plant or animal population can affect a food chain.

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# Teacher Background

The following background information has been provided in order to help the teacher answer student questions.

Food chains and webs explain how energy moves through a community. They do not, however, explain how much energy passes from one step in a food chain to another. While an organism undergoes life functions, it loses energy in the form of heat. Because of energy loss at each step of the food-energy transfer, the amount of energy available to the next level has decreased.

In a community you have three types of inhabitants.

1. A producer is an organism that takes the sunlight and transforms it into useable energy in the form of starches and sugars. Plants are the only organisms that can do this job.
2. Animals can't make their own food so they must find food to eat. Animals are consumers because they eat things. There are two types of consumers.
  - A. Primary consumers are animals that only eat plants (herbivores).
  - B. Secondary consumers are animals that eat both plant and animals (omnivores), or animals that eat only other animals (carnivores).
3. A decomposer is an organism that breaks down dead or decaying plant and animal matter. Without decomposers the nutrients stored in the dead material couldn't be reused by other organisms.

A food chain is a pathway of energy through a community. The following is an example of a food chain. The direction of the arrow indicates the flow of energy within a community. For example, the grass captures energy from the sun for photosynthesis, the grasshopper eats the grass to get energy, and in turn the bird eats the grasshopper to get energy.

Sun → Grass → Grasshopper → Bird

The food chain concept is useful for tracing chemical recycling and energy flow in an ecosystem, but food chains do not exist by themselves. This means that organisms in a natural ecosystem are interwoven together into a complex network called a food web.

When working with food chains and webs students need to be aware of possible problems that could occur to the animals or plants in the food chain or web. Students need to also be aware of the impact a plant or animal has on others when it becomes endangered, threatened, rare, or extinct.

**Threatened:** Any native species or subspecies of animal or plant that, although not presently threatened with extinction, is likely to become an endangered species within the foreseeable future in the absence of the species' protection and management efforts.

**Endangered:** Any native species or subspecies of animal or plant which is in serious danger of becoming extinct throughout all or most of its range due to one or more causes. Causes include loss of habitat, change in habitat, overexploitation, predation, competition or disease.

**Rare (plants only):** Although the species is not presently threatened with extinction, it exists in such small numbers throughout all or most of its range that it may become endangered if its environment worsens.

**Extinct:** Any native species or subspecies of animal or plant that is no longer alive.

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# Lesson 1

## Activities

### Materials

1. One copy of the food chain list for each student.
2. Construction paper, magazines and white drawing paper.
3. Rulers, colored pencils, and glue for each group.

### Focusing

1. Have the students tour the school ground and, using the food chain list, have them write down the animals that they observe on or around the school.
2. Then have the students write down what these animals eat (plant and animal food sources). Library research may be necessary.

### Finding Out

1. Have the students choose an animal from the list. Then have the students identify the plants and animals it eats.
2. Have the teacher explain what a food chain is by using the background information provided.
3. Using the animal that they chose from #1, have the students make a food chain. Also give the students information on what endangered, threatened, rare and extinct mean.
4. Choose one plant and one animal in the food chain and make them endangered. How does this affect your food chain?

### Bridging

1. Make a game that illustrates how a food chain works and the impact that occurs when a plant or animal becomes endangered or extinct.

## **Assessment**

1. The student will be able to demonstrate an understanding of how a food chain works by using two different media to display this knowledge (i.e., essay, oral communication, poster, model, etc.)
2. The student will be able to display in a game, problem-solving skills that demonstrating how species extinction affects a food chain.

## Food Chain Chart

Animals from local area are listed separately in each side box. Then fill in what they eat. (Each row should include both plants and animals if that animal eats both. Try and be name specific, i.e. "grass," not "plant;" "grasshopper," not "bug.")

Animals	What they eat.



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# The Web of Life

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## Lesson 2

**Lesson Summary** Students will explain what an energy pyramid is. Students will identify what parts of their diet are composed of plant and animal and then will determine how they could change their diet to be more efficient in using energy.

**General Goal** To introduce students to what the components of an energy pyramid are and how what they eat affects the amount of consumers that can be supported by an ecosystem.

**Duration** 3 or 4 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Recognize the various steps in an energy pyramid.
2. Explain how changes in eating habits can impact the number of organisms the planet can support.

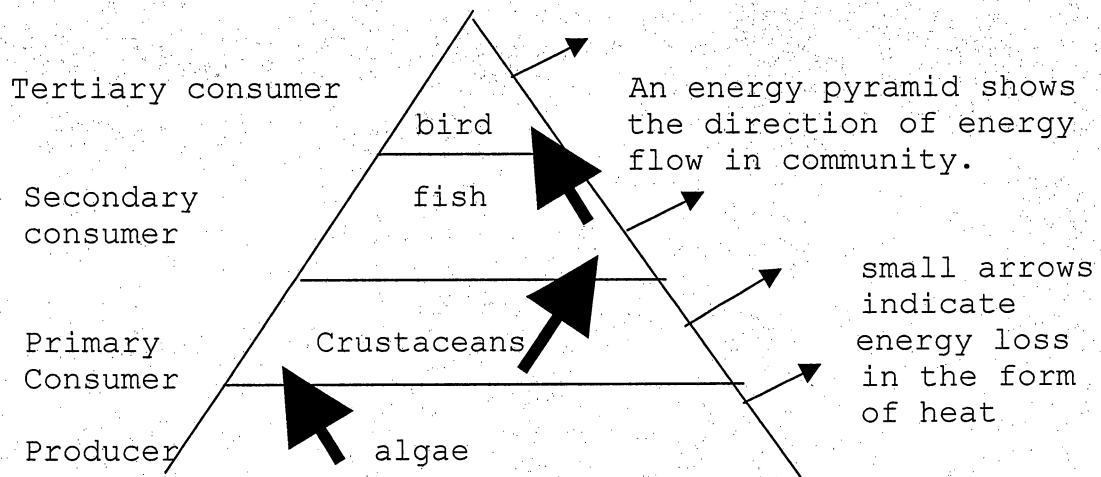
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# Teacher Background

The following background information has been provided in order to help the teacher answer student questions.

## Energy Pyramids

The energy pyramid concept communicates the idea that as energy passes along a food web, fewer and fewer organisms become involved. This is the case in the pond chain illustrated below.



At each transfer from one level to the next, work is done in the form of heat. Low-quality heat is given off to the environment, and high-quality energy is stored in that organism in the form of fat, proteins and carbohydrates. Another may then eat this organism in order to can energy from its stored fats, proteins and carbohydrates.

The percentage of available high-quality energy transferred from one organism to the next is between 2%-30%, depending on the type of species involved. The greater the number of levels in the energy pyramid or food

web the more loss of usable high-quality energy there is from bottom to top. Therefore the farther away from the bottom of the pyramid the fewer organisms will be supported. The bottom of the pyramid is very large because it gets its energy directly from the sun and is able to support the largest amount of life.

The energy flow pyramid explains how a larger population of people might be supported if people shortened the food chain by eating plants directly rather than eating animals fed by those plants.

---

# Lesson 2

## Activities

### Materials

1. Food chain from lesson 1.
2. Construction paper and markers.
3. Food Chart.

### Focusing

1. Have students estimate how much of their diet is made up of plant matter and animal matter. Have them list the items on the Food Chart in the appropriate category.
2. Which part of their diet, plant or animal, do the students think take more energy and resources to produce?
3. Make sure students understand that they also need to consider how far the food they eat has to travel to get to them. This also consumes energy. Examples would be eating fruit grown in Hawaii instead of oranges grown right here. Where meat comes from also needs to be considered, such as, eating chicken that has travel on average 2000 miles instead of getting meat products from local ranchers.

### Finding Out

1. Have the students make an energy pyramid for the food chain from lesson 1. The teacher should provide the student with information on what a food pyramid is by examples and the information in the teacher background.
2. Have the students look at the food chain they made. Which animals use the least amount of energy, and which animals use the most energy?

## **Bridging**

1. Have the students make an energy pyramid for animal products they eat and plant products they eat.
2. Have the students compare the number of energy levels for the plants and the animals that they eat. Which one is more energy efficient (don't forget about travel expense)?
3. As the population grows what changes to our diet will be necessary in order to feed more people?

## **Assessment**

1. They will be able to identify the components that make up an energy pyramid.
2. They will be able to explain how our diet needs to change in order to feed more people.

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# The Web of Life

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## Lesson 3

**Lesson Summary** Students will construct a food web from the list of animals from lesson 1. They will explain the impact of species loss to a food web community.

**General Goal** To introduce students to what the components of a food web is and how species extinction can affect it.

**Duration** 3 or 4 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Recognize the various steps in a food web.
2. Identify the different parts of the food web and identify them as producers, primary consumers, secondary consumers or decomposers.
3. Explain how a change in plant or animal population can affect a food web.

---

# Lesson 3

## Activities

### Materials

1. The food chain chart from lesson 1.
2. Construction paper and white drawing paper.
3. Rulers, colored pencils, and glue for each group.

### Focusing

1. Have the students make a food chain for each of the remaining animals on the food chain chart from lesson 1.

### Finding Out

1. Have the students then put these food chains together where one or more of the different plants and animals are the same.
2. Have the students use a large piece of construction paper to make a clear diagram of the food web for the community members.

### Bridging

1. Have the students remove one of the plants on the food web to emulate its extinction.
2. What are the consequences of this action? What happens to the animal population that uses this plant for food?
3. Research the types of plants that that animal eats. Is there another plant that the animal could substitute for it that is also found in the community? If this occurs, how would it affect other animals that also eat the other plants?

## **Assessment**

1. The student will identify the various parts that make up a food web.
2. The student will be able to explain the effects of species extinction for members in the food web.



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# The Web of Life

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## Lesson 4

**Lesson Summary** Students will identify within the region that they live an endangered or threatened plant or animal. They will then research that plant or animal to find out why it has become threatened or endangered.

**General Goal** To introduce students to why plants and animals could become endangered, threatened or extinct.

**Duration** 5 or 6 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Explain what extinction, endangered and threatened means.
2. Identify some of the reason why plants and animals become extinct, endangered or threatened.
3. Suggest steps could be taken in order to help save a threatened or endangered species.

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# Lesson 4

## Activities

### Materials

1. Time to research the plant or animal that they have chosen at the school library, on the Internet, or at the public library.
2. California Endangered Species Resource Guide (information for this guide is in Appendix D)

### Focusing

1. Ask the students to choose an endangered or threatened animal or plant from the California Endangered Species Resource Guide. The plant or animal chosen should be from the area that they live in.
2. Have the student determine the main reason for that species decline in population. The students will require research time to find this out.

### Finding Out

1. Have the students determine if the endangerment of the species falls into the following categories: commercial exploitation and predator control, pesticides and poisoning, introduction of new exotic species, or loss of habitat.
2. What effect will the extinction of this species have on the community in which it lives? What animals are dependent upon it for food? How will the decreased number of these animals affect our lives?

## **Bridging**

1. Have the students write an article about his/her endangered plant or animals.
2. Have them write an article that explains what caused it to become endangered or threatened. Who or what will be affected by its extinction?
3. Then have the student suggest ways to improve the status of (endangered or threatened) his/her plant or animal within the community.

## **Assessment**

1. The student will be able to identify why an animal or plant has become endangered or threatened.
2. The student will be able identify what affects a species becoming endangered or threatened could have on its community.
3. The student will suggest solutions that could help improve the status of his/her plant or animal.

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# Unit 3

## Not Just a Wasteland.

**Subject** Environmental Science, Science

**Grade** 11th-12th grade

**Topic** World Biomes

**Subtopic** Deserts and their occupants

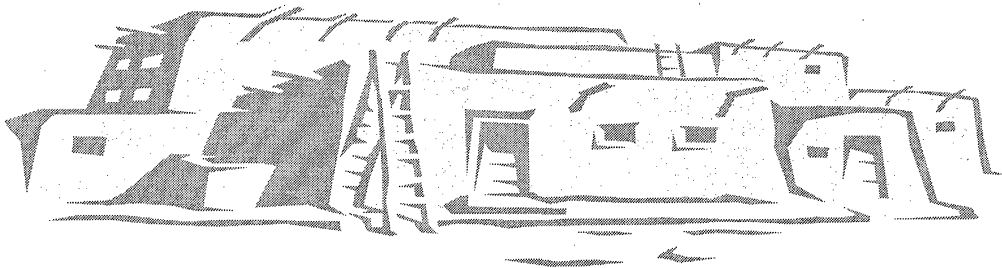
**Topic** Human Impact,

**Subtopic** Conservation, Habitat, Population

**Topic** Ecological Concepts,

**Subtopic** Adaptations of plants

**Unit Issue** This unit addresses the following issue of how population growth of humans is affecting desert populations.



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# Not Just a Wasteland

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## Lesson 1

**Lesson Summary** Students will identify a variety of plants and animals that live in desert climates. The students will determine what types of adaptations these plants and animals have in order to live in desert climates.

**General Goal** To introduce students to the variety of life found in the desert and help them understand how humans have impacted the inhabitants of the desert.

**Duration** 3 or 4 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Explain what a desert is.
2. Recognize the various inhabitants that live in desert regions.
3. Identify some of the endangered species that live in our local deserts.

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# Teacher Background

The following information has been provided in order to help the teacher identify specific desert types in order to instruct students on what a desert is and what types of plants and animals live in a desert.

## Background information on deserts

**Desert**, term applied to regions of the earth that are characterized by less than 254 mm (10 inches) of annual rainfall, an evaporation rate that exceeds precipitation, and, in most cases, a high average temperature. Because of a lack of moisture in the soil and low humidity in the atmosphere, most of the sunlight penetrates to the ground. Daytime temperatures can reach 55° C (131° F) in the shade. At night the desert floor radiates heat back to the atmosphere, and the temperature can drop to near freezing.

A combination of climate patterns and geological features cause deserts.

### What is the Desert?

We think of deserts as areas of extreme heat and dryness. Deserts, or arid regions of the world, characteristically receive less than 10 inches of rainfall annually. In some deserts, the amount of evaporation is greater than the amount of rainfall. Semiarid regions average 10-20 inches of annual precipitation. Typically, desert moisture occurs in brief intervals and is unpredictable from year to year. About one-third of the earth's landmass is arid (either desert or semidesert).

Various factors contribute to aridity. Rising air cools and can hold less moisture, producing clouds and precipitation. Falling air warms, absorbing moisture. Areas with few clouds, bodies of water and little vegetation absorb most of the sun's radiation, thus heating the air at the soil surface. More humid areas deflect heat in clouds, water and vegetation, remaining cooler. High wind in open country also contributes to evaporation.

Locations of deserts have changed throughout geologic time as the result of continental drift and the uplifting of mountain ranges. Modern desert regions are centered in the horse latitudes, typically straddling the Tropic of Cancer and the Tropic of Capricorn, between 15 and 30 degrees north and south of the equator. Some deserts, such as the Kalahari in central Africa, are geologically ancient. The Sahara Desert in northern Africa is 65 million years old, while the Sonoran Desert of North America reached its northern limits only within the last 10,000 years. Because they are poised in such harsh extremes of heat and aridity, deserts are among the most fragile ecosystems on the planet.

In most modern classifications, the deserts found in the United States and adjacent northern Mexico are grouped into four categories: Chihuahuan, Sonoran, Mojave and Great Basin. The distinctions are made on the basis of floristic composition -- the species of plants growing in a particular desert. The geologic history of a region, the soil and mineral conditions, and the patterns of precipitation determine plant communities, in turn.

Three of our deserts -- the Chihuahuan, the Sonoran and the Mojave -- are called "hot deserts" because of their high temperatures during the long summer. These three are also called "Mexican deserts" because the evolutionary affinities of their plant life are largely with subtropical plant communities to the south. The Great Basin Desert is called a "cold desert" because its dominant plant life is not subtropical in origin.

### **Desert Plant Survival**

Desert plants have adapted to the extremes of heat and aridity by using both physical and behavioral mechanisms, much like desert animals.

Plants that have adapted by altering their physical structure are called xerophytes. Xerophytes, such as cacti, usually have special means of storing and conserving water. They often have few or no leaves, which reduces transpiration.

Phreatophytes are plants that have adapted to arid environments by growing extremely long roots, allowing them to acquire moisture at or near the water table.

Other desert plants, using behavioral adaptations, have developed a lifestyle in conformance with the seasons of greatest moisture and/or coolest temperatures. These types of plants are usually (and inaccurately) referred to as perennials -- plants that live for several years, and annuals -- plants that live for only a season.

Desert perennials often survive by remaining dormant during dry periods of the year, then springing to life when water becomes available.

Most annual desert plants germinate only after heavy seasonal rain, then complete their reproductive cycle very quickly. They bloom prodigiously for a few weeks in the spring, accounting for most of the annual wildflower explosions of the deserts. Their heat- and drought-resistant seeds remain dormant in the soil until the next year's annual rains.

### **Xerophytes**

The physical and behavioral adaptations of desert plants are as numerous and innovative as those of desert animals. Xerophytes, plants that have altered their physical structure to survive extreme heat and lack of water, are the largest group of such plants living in the deserts of the American Southwest.

Each of the four southwestern deserts offers habitats in which most xerophytic plants survive. But each is characterized by specific plants that seem to thrive there. The Great Basin Desert is noted for vast rolling stands of Sagebrush and Saltbush, while in the Mojave Desert, Joshua Trees, Creosote Bush, and Burroweed predominate. The Sonoran Desert is home to an incredible variety of succulents, including the giant Saguaro Cactus, as well as shrubs and trees like mesquite, Paloverde, and Ironwood. The Chihuahuan Desert is noted for mesquite ground cover and shrubby undergrowth like the Yucca, and Prickly Pear.

Cactus, xerophytic adaptations of the rose family, are among the most drought-resistant plants on the planet due to their absence of leaves, shallow root systems, ability to store water in their stems, spines for shade and waxy skin to seal in moisture. Cacti originated in the West Indies and migrated to many parts of the New World, populating the deserts of the Southwest with hundreds of varieties such as the Beavertail Cactus and the Jumping Cholla.

Cacti depend on chlorophyll in the outer tissue of their skin and stems to conduct photosynthesis for the manufacture of food. Spines protect the plant from animals, shade it from the sun and also collect moisture. Extensive shallow root systems are usually radial, allowing for the quick acquisition of large quantities of water when it rains. Because they store water in the core of both stems and roots, cacti are well suited to dry climates and can survive years of drought on the water collected from a single rainfall.

Many other desert trees and shrubs have also adapted by eliminating leaves -- replacing them with thorns, not spines -- or by greatly reducing leaf size to eliminate transpiration (loss of water to the air). Such plants also usually have smooth, green bark on stems and trunks serving to both produce food and seal in moisture.

### **Phraetophytes**

Phraetophytes like the mesquite tree have adapted to desert conditions by developing extremely long root systems to draw water from deep underground near the water table. The mesquite's roots are considered the longest of any desert plant and have been recorded as long as 80 feet. Botanists do not agree on the exact classification of the three-mesquite trees: the Honey Mesquite, Screwbean Mesquite and the Velvet Mesquite, but no one disputes the success of their adaptation to the desert environment. Mesquites are abundant throughout all the southwestern deserts.

The Creosote Bush is one of the most successful of all desert species because it utilizes a combination of many adaptations. Instead of thorns, it relies for protection on a smell and taste wildlife find unpleasant. It has tiny leaves that close their stomata (pores) during the day to avoid water loss and open them at night to absorb moisture. Creosote has an extensive double root system -- both radial and deep -- to accumulate water from both surface and ground water.

### **Perennials**

Some perennials like the Ocotillo, survive by becoming dormant during dry periods, then springing to life when water becomes available. After rain falls, the Ocotillo quickly grows a new suit of leaves to photosynthesize food. Flowers bloom within a few weeks, and when seeds become ripe and fall, the Ocotillo loses its leaves again and re-enters dormancy. This process may occur as many as five times a year. The Ocotillo also has a waxy coating on stems, which serves to seal in moisture during periods of dormancy.

Another example of perennials that utilize dormancy as a means of evading drought are bulbs, members of the lily family. The tops of bulbs dry out completely and leave no trace of their existence above ground during dormant periods. They are able to store enough nourishment to survive for long periods in rocky or alluvial soils. The Desert Lily, also known as the Ajo, is found at a depth of 18 inches or more. Adequate winter rains can rouse it to life after years of dormancy.

### **Annuals (Ephemerals)**

The term "annuals" implies blooming yearly, but since this is not always the case, desert annuals are more accurately referred to as "ephemerals." Many of them can complete an entire life cycle in a matter of months, some in just weeks.

Contrary to the usual idea that deserts are uniformly hot, dry and homogeneous in their lack of plant life, they are actually biologically diverse and comprise a multitude of microclimates changing from year to year. Each season's unique precipitation pattern falls on a huge variety of mini-environments. And each year in each of these tiny eco-niches, a different medley of plants bloom as different species thrive.

Desert plants must act quickly when heat, moisture and light inform them it's time to bloom. Ephemerals are the sprinters of the plant world, sending flower stalks jetting out in a few days. The peak of this bloom may last for just days or many weeks, depending on the weather and difference in elevation. The higher one goes, the later blooms come. Different varieties of plants will be in bloom from day to day, and even hour to hour, since some open early and others later in the day.



Ephemerals such as the Desert Sand Verbena, Desert Paintbrush and Mojave Aster usually germinate in the spring following winter rains. They grow quickly, flower and produce seeds before dying and scattering their progeny to the desert floor. These seeds are extremely hardy. They remain dormant, resisting drought and heat, until the following spring -- sometimes 2 or 3 springs -- when they repeat the cycle, germinating after winter rains to bloom again in the spring. There are hundreds of species of ephemerals that thrive in the deserts of the American Southwest.

If you examine desert soils closely, you will dispel forever any notion you might have of the desert as a barren environment, for you will likely find dozens of both annual and perennial seeds in every handful of desert soil. In the Sonoran Desert, seed densities average between 5,000 and 10,000 per square meter. The world record is over 200,000 seeds per square meter.

This "seed bank" attests to the remarkable reproductive success of desert flora, made possible by their symbiotic relationship with desert fauna -- birds, insects, reptiles and even mammals. Animals aid in both fertilization and dispersion of seeds, assuring the continued profusion and diversity of plant life throughout the deserts of the Southwest.

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# Lesson 1

## Activities

### Materials

1. Access to desert books in the school library or in a public library.
2. Copy of the outline for a field guide page.
3. California Endangered Species Resource Guide (in resource guide section)

### Focusing

1. Asks the students to write a paragraph describing what they think of when they here the word desert. Have a few students (who want to) share their writings.
2. Have the students look at books or watch a movie about deserts. These materials can be obtained from school or public libraries and from school video resources.

### Finding Out

#### In cooperative learning groups;

1. Have the students gather sample pictures of the plants (real ones if possible) found in deserts, and then separate them into groups based on similar characteristics such as size, leaf shape, leaves present, or modifications to leaves, by either seeing live plants (fieldtrip) or by viewing pictures in a book about desert plants.
2. Have the students gather sample pictures of the animals (real ones if possible) found in deserts, and then separate them into groups based on similar characteristics such as breeding habits, times of activity, or food gathering habits, by either seeing live plants (fieldtrip) or by viewing pictures in a book about desert animals.

## **Bridging**

1. Have the students identify any plants and animals that are on the threatened or endangered list from the California Endangered Species Guide that can be found in the local deserts.
2. Why are the plants and animals endangered or threatened that you identified? Have the students find information on the plant or animal in the desert in order to learn about its feeding, breeding and living needs. Which one(s) of these have been changed to cause the endangered or threatened status?

## **Assessment**

1. The student will be able to identify one endangered or threatened plant or animal species in the area.
2. The student will be able to identify reasons why the plant or animal is endangered or threatened.

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# Not Just a Wasteland

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## Lesson 2

**Lesson Summary** Students will identify specific adaptations that plants and animals have in order to survive in the harsh desert environment.

**General Goal** To introduce students to the desert and help them understand the specialized characteristics desert plants and animals have in order to survive in the desert.

**Duration** 4 or 5 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Explain what adaptation is.
2. Recognize specialized features of plants that allow them to survive in the desert.
3. Recognize some of the special characteristics animals have in order to survive in the desert.
4. Identify some of the endangered species that live in our local deserts and how humans are impacting their habitats.

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# Teacher Background

The following information has been provided in order to help the students write a poem.

Have the students find a picture of the plant/animal that they are going to write the poem about. The student needs to write a poem that is positive about them through the plant or animal. The poem should have at least four positive thoughts. The following are examples to help the students get started.

**I am like a rock.**

**A rock is solid and not easily moved.**

**A rock has many faces for the daily trials of life.**

**A rock is always under foot giving support.**

**A rock can make many mountains unique in shape.**

**I am like the wind.**

**The wind shapes things that come into its path.**

**The wind helps birds fly high in the sky.**

**The wind brings relief when the days get hot.**

**The wind is mild, but can be strong.**

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# Lesson 2

## Activities

### Materials

1. Construction paper, colored pens and pencils.
2. California Endangered Species Resource Guide (in resource guide section)

### Focusing

1. Have the teacher read some examples of poems from the teacher background information.
2. Have the students write a poem for one of the endangered plants or animals in the local area utilizing the information from lesson 1.

### Finding Out

1. Have the students determine what the most common adaptations are for the plants or animals found in the local Inland Empire deserts. They can use the information gathered in lesson 1 and they should gather information about the leaves, roots and stem systems in these plants. They should also research the habits of the animals to see how they have adapted.
2. Have the students determine how the desert plants and animals use these adaptations in order to survive in the desert ecosystems.
3. What would happen if you took a desert plant or animal and moved it to a forest? What would happen if you took a forest plant or animal and moved it to the desert? Can desert plants and animals survive in a wider range of climates due to their specialized adaptations?

## **Bridging**

1. Have the students produce a poster of the endangered plant or animal along with the poem that they wrote.
2. Have the students edit these posters in groups so that it may be displayed at the students school site.

## **Assessment**

1. The student will be able to identify specific adaptations that desert plants or animals have.
2. The student will show concern for the endangered or threatened plant or animal in the form of a poem and a poster.

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# Not Just a Wasteland

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## Lesson 3

**Lesson Summary** Students will identify a variety of ways that humans are encroaching upon the desert habitats.

**General Goal** To have the students identify ways that humans have impacted desert habitats.

**Duration** 5 to 6 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Identify ways that humans are impacting desert habitats.
2. Explain on way that a specific desert area will be affected.
3. Be able to identify who will benefit from using desert areas.



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# Teacher Background

The list below has been provided in order to help direct students in finding a local issue related to deserts. Please post or make copies for students to view. Information about these proposed plans is public domain and can be obtained by writing, calling or E-mailing your local Land Management Bureau. Most information can be obtained within a week. Many of these proposals are currently posted on the Internet at the BLM homepage or at many of the links at the BLM homepage.

The Bureau of Land Management (BLM) has listed several projects that affect the following areas: Needles Recreational Area, Barstow Recreational Area, Ridgecrest Recreational Area, and El Centro Recreational Area.

The following are a list of current proposals that are being reviewed by the BLM. Information can be obtained from the BLM about these proposals.

1. Fort Irwin Expansion
2. Castle Mountain Mine Proposal
3. Bolo Station
4. Barstow Resource Area - County Solid Waste Program
5. Apex Mine
6. Ord Mountain Pilot Project
7. Recreational Fee Proposal
8. Ward Valley Proposal for Low Level Radioactive Waste Facility
9. Afton Canyon clean up
10. Wild Burro Removal Project for the Colorado River, Imperial Dunes and Yuha Desert
11. Catellos Land Exchange
12. Agreement upon Wilderness Boundaries and who will manage them

13. Clean up of Navy Facility near the Salton Sea
14. Eagle Mountain Project
15. Desert Tortoise Natural Area
16. Marine Corp Wilderness Trespass
17. East Harper Fence

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# Lesson 3

## Activities

### Materials

1. Copy of Teacher Background
2. Access to public and school libraries and the Internet.
3. California Endangered Species Resource Guide (in resource guide section)
4. Map of Barstow Area, El Centro Area, Ridgecrest Area, and Needles Area. (Can be obtained from a Map reproduction Company)

### Focusing

1. Ask the students in groups of 4 or 5 to choose one of the topics from the Teacher Background information.
2. Have the students locate on the appropriate map where their proposal will take place.

### Finding Out

1. Have the students access the type of area that is around the proposal area, such as rivers, lakes, mountains, wildlife areas, park and recreational sites, etc.
2. What are the populated areas around the proposed site?
3. Have the students identify any endangered or threatened species that live in the proposed area. They can do this by first using the California Endangered Species Resource Guide. Then they will need to use other references in order to make sure that their information is accurate for that area.

## **Bridging**

1. Have the students in groups present what the proposal is that they picked and who the proposal would benefit.

## **Assessment**

1. The student will be able to identify how humans have impacted animals and plants.
2. The student will be able to identify who might benefit by using the desert areas.

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# Not Just a Wasteland

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## Lesson 4

**Lesson Summary** Students will identify the various players on one issue occurring in a local desert area.

**General Goal** To introduce students to the impact humans have on desert habitats and to have them suggest ways that human and native desert inhabitants can co-exist.

**Duration** 6 or 7 class periods lasting 55 minutes long.

### Learning Objectives

Upon completion of this lesson, students will be able to:

1. Identify the various players involved in an issue.
2. Suggest a variety of options that could be used to solve the issue.
3. Provide possible steps that could be taken to enact this plan.

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# Teacher Background

The students will need access to public libraries, Internet services and newspaper articles in order to research the issue.

The following new terms will need to be discussed with the students prior to the lesson.

**Players:** This refers to the various people involved in a dispute or issue. These may be identified as the opponents or proponents.

**Opponent:** This refers to people who against the proposed changed or proposal.

**Proponent:** This refers to people who support the change or new proposal.

**Position:** This refers to the opinion that a person holds on an issue.

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# Lesson 4

## Activities

### Materials

1. Information from Lesson 3.
2. Continued access to public and school libraries and the Internet. A phone or phone calls may be necessary to contact the various Land Management Agencies overseeing those areas.

### Focusing

1. Have the students identify the opponents and proponents of the proposal. Examples could be local farmers, off road enthusiasts, city officials, local inhabitants, environmentalists, etc. It will depend upon the specific proposal that has been chosen.
2. This can be done by getting articles that have been published in the local papers by the various sides (public libraries keep newspapers from the local papers), and looking at articles published on the Internet. The Bureau of Land Management has several links to areas where people publish information about the current proposals. Much information about various attitudes can be gathered from these sites. Also the BLM has posted any actions that have been filed and where the information can be procured from if it is not located currently on the Internet.

## **Finding Out**

1. Have the students list the various people/groups involved. Have them make lists of Proponents and the other of Opponents.
2. What do the proponents have in common? What is the most common reason for supporting the proposal?
3. What do the opponents have in common? What is the most common reason for rejecting the proposal?
4. Is there any one group that will benefit more by the proposal being passed or not being passed?

## **Bridging**

1. Have the students access the advantages and disadvantages of the proposal by making a list of what the various sides have used to argue for or against the proposal.
2. Have the group review the list and then present their recommendations and the reasons why to the class.
3. This will be a follow up to the previous presentation of the proposal. The students will then present the advantages and disadvantages as they see them for the proposal.
4. The students will also evaluate the advantages and disadvantages and give a statement for or against the proposal with a convincing argument.

## **Assessment**

1. The student will be able to identify the various people or groups involved in the proposal.
2. The student will be able identify the advantages and disadvantages of the proposal.
3. The students will provide a convincing argument for or against the proposal.



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# Unit 4

## The O's Have It

**Subject:** Environmental Science, Science

**Grade:** 11th -12th grade

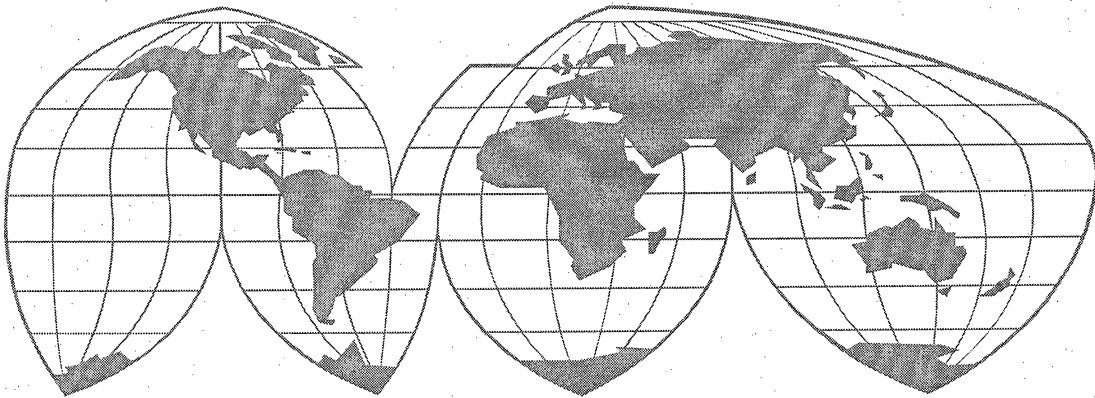
**Topic:** Human Impact

**Subtopic:** Population Growth and Attitudes towards the Environment

**Topic:** Environmental Ethics and Health Issues

**Subtopic:** Ozone layer, Health problems and Global warming

**Unit Issue:** This unit addresses how humans have impacted the ozone layer and how it will affect the way we live in the future.



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# The O's Have It

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## Lesson 1

**Lesson Summary:** Students will identify what the ozone layer is, how it is made and what types of pollution are destroying it.

**General Goal:** To introduce students to the ozone layer and how humans are impacting it.

**Duration:** 3 or 4 class periods lasting 55 minutes long.

### Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Explain what the ozone layer is and where it is found.
2. Explain how ozone is made and where ozone depletion is occurring.
3. Recognize the various ways in which CFCs play a part in ozone depletion.

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# Teacher Background

The following background information has been provided in order for the teacher to explain to students how to play the ozone game and to prepare the pieces necessary for playing the ozone game. Additional background information has also been provided on the ozone layer in order to help the teacher answer and guide student questions.

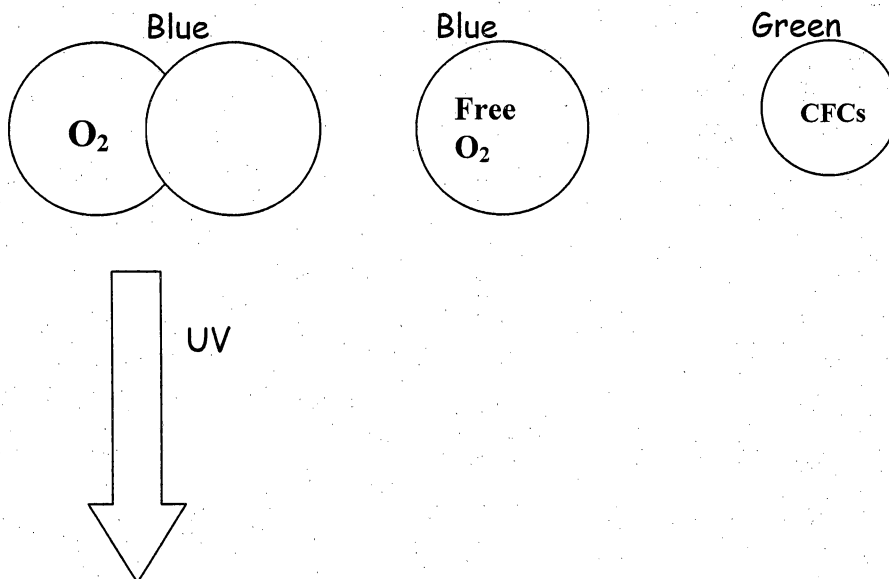
## Vocabulary

**CFC = Chlorofluorocarbons**, were used extensively in aerosols, air conditioners, refrigerators, and cleaning solvents as a propellant.

## Ozone Game

### Procedures:

Make the following pieces



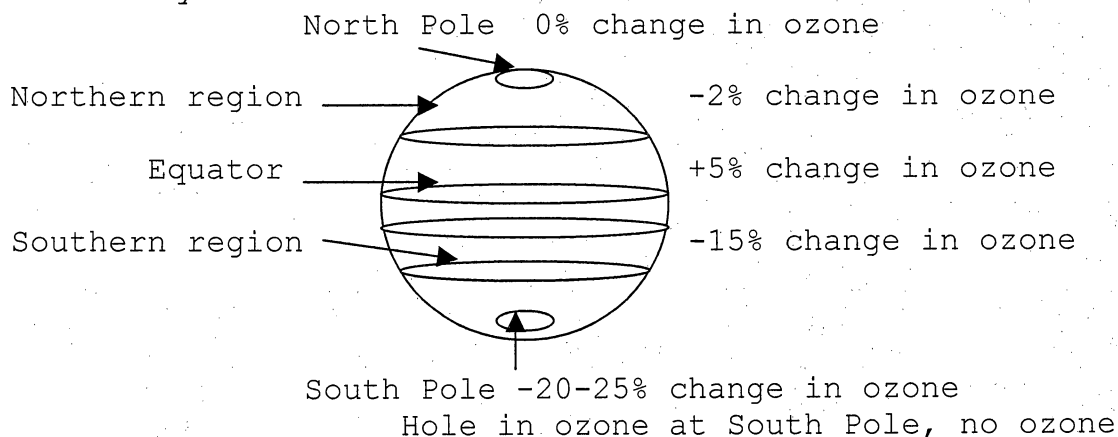
For each of the following areas make:

Area	O <sub>2</sub>	Free Oxygen	CFCs	UV Violet
North Pole	4	4	2	2
South Pole	4	4	2	0
Equator	4	4	2	1
Northern Region	4	4	2	2
Southern Region	4	4	2	2

### Ozone Game Rules

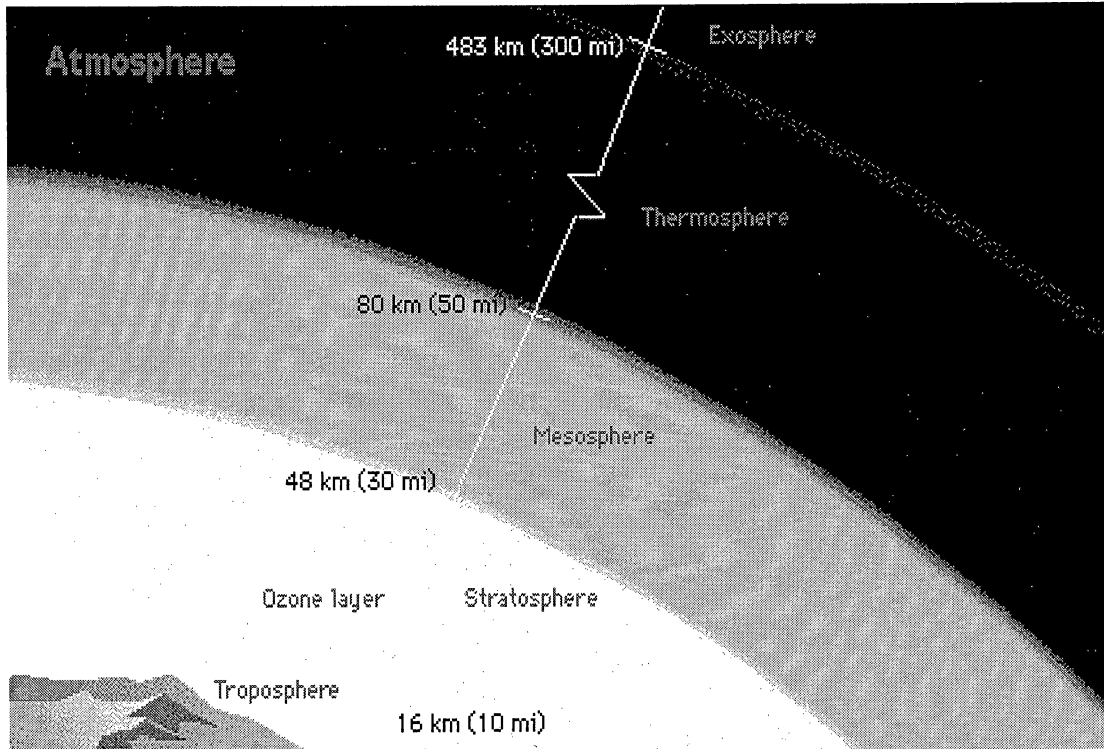
1. Divide the students into groups so that each group represents a region of the world. Do not tell them which region they represent.
2. Then give the students the Ozone pieces. One O<sub>2</sub> and one free oxygen make an O<sub>3</sub> ozone molecule. Have them arrange the pieces into an ozone layer with the ozone molecules.
3. Once each group has made their protective ozone layer give them the pollution (CFCs) and UV radiation envelope.
4. Ozone molecules may be broken up and rebuilt as many times as possible.
5. The pollution molecules and UV rays can only be used once for each piece and then they are put into the used pile.

6. For each pollutant the damage it does to the ozone is as follows:
  - A. CFCs is a chemical used as a propellant in aerosol cans, and is a component of freon in air conditioning units and old refrigeration units. The CFCs then breaks apart in the upper atmosphere after about forty years causing free chlorine molecules to appear. The chlorine in a CFC molecule takes 2 ozone molecules and breaks them into  $3O_2$ .
7. For each UV ray the damage or help that it does to the ozone is as follows:
  - A. An ozone molecule can block ultra-violet radiation (UV) if one is available. In the process of blocking the harmful UV rays the ozone molecule breaks apart into  $O_2$  and free oxygen. If no ozone protection is available then the UV rays reach the earth causing skin cancer and other health problems.
  - B. If you have  $O_2$  and Free Oxygen it will create on  $O_3$  ozone molecule automatically.
8. With the various pieces of pollution and UV rays have the groups break and then remake the ozone until all of the pieces have been used to the best of their ability. Depending on where which region of the world, not all of the pieces may be able to be used. Determine how much ozone you have left, if any.
9. From the remaining ozone determine in what part of the world you live.



## Background Information on Ozone

The following background information can either be distributed as is to the students or the teacher may prepare and information sheet from the following ozone background information. Additional background information can be obtained from the following web site ([www.epa.gov](http://www.epa.gov)).



### **Ozone Facts**

- The ozone layer is located within the stratosphere, about 15 miles above the earth's surface.
- The stratosphere is the second major strata of air in the atmosphere.
- Ozone plays the major role in regulating the thermal regime of the stratosphere, as water vapor content within the layer is very low.
- Temperature increases with ozone concentration.
- Solar energy is converted to kinetic energy when ozone molecules absorb ultraviolet radiation, resulting in heating of the stratosphere.
- Approximately 90 % of the ozone in the atmosphere resides in the stratosphere.

- Ozone concentration in this region is about 10 parts per million by volume as compared to approximately 0.04 parts per million by volume in the troposphere.
- Ozone absorbs the bulk of solar ultraviolet radiation in wavelengths from 290 nm - 320 nm.
- Meteorological conditions strongly affect the distribution of ozone.
- Most ozone production and destruction occurs in the tropical upper stratosphere, where the largest amounts of ultraviolet radiation are present.
- The amount of ozone required to shield Earth from biologically lethal UV radiation, wavelengths from 200 to 300 nanometers (nm), is believed to have been in existence 600 million years ago.
- The atmosphere we breathe is a relatively stable mixture of several gases, the major components of this region, by volume, are oxygen (21%), nitrogen (78%), and argon (0.93%).
- Stratospheric ozone is created and destroyed primarily by ultraviolet radiation.
- The air in the stratosphere is bombarded continuously with ultraviolet radiation from the Sun. When high-energy ultraviolet rays strike molecules of ordinary oxygen (O<sub>2</sub>), they split the molecule into two single oxygen atoms.
- The free oxygen atoms can then combine with oxygen molecules (O<sub>2</sub>) to form ozone (O<sub>3</sub>) molecules.

## **Anthropogenic Destruction**

- Manufactured compounds are also capable of altering atmospheric ozone levels. Chlorine, released from CFCs, and bromine (Br), released from halons, are two of the most important chemicals associated with ozone depletion.
- Halons are primarily used in fire extinguishers. CFCs are used extensively in aerosols, air conditioners, refrigerators, and cleaning solvents.
- CFCs were originally created to provide a substitute for toxic refrigerant gases and reduce the occupational hazard of compressor explosions. Near Earth's surface, chloroflourocarbons are relatively harmless and do not react with any material, including human skin.
- For 50 years they appeared to be the perfect example of a benign technical solution to environmental and engineering problems, with no negative side effects.
- While CFCs remain in the troposphere they are virtually indestructible. They are not water-soluble and cannot even be washed out of the atmosphere by rain
- CFCs remain in the troposphere for more than 40 years before their slow migration to the stratosphere is complete.
- In the stratosphere, high-energy ultraviolet radiation causes the CFC molecules to break down through photodissociation.
- Atomic chlorine, a true catalyst for ozone destruction, is released in the process.

- Chlorine initiates and takes part in a series of ozone destroying chemical reactions and emerges from the process unchanged.
- The free chlorine atom initially reacts with an unstable oxygen-containing compound, such as ozone, to form chlorine monoxide (ClO).
- The chlorine monoxide then reacts with atomic oxygen to produce molecular oxygen and atomic chlorine.
- The regenerated chlorine atom is then free to initiate a new cycle.
- This destructive chain of reactions will continue over and over again, limited only by the amount of chlorine available to fuel the process.
- CFC-12 concentrations were less than 100 parts per trillion by volume when they were first measured in the 1960s.
- Between 1975 and 1987, concentrations more than doubled from less than 200 parts per trillion by volume to more than 400 parts per trillion by volume.
- Polar regions reflect the greatest changes in ozone concentrations, especially the South Pole.
- The air stays within this polar vortex all winter, becoming cold enough to allow the formation of polar stratospheric clouds.
- Polar stratospheric clouds speed up the natural process of ozone destruction by providing ice crystal surfaces on which the destructive reactions take place.
- In the Southern Hemisphere, the area of most severe ozone depletion is localized above Antarctica and is generally referred to as the ozone hole.
- Ozone levels in the atmosphere have been monitored from the ground since the 1950s and by satellite since the 1970s.
- Regional total ozone levels measured from satellites over Antarctica have decreased 30-50% since their monitoring began.



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# Lesson 1

## Activities

### Materials

For each student copy the following materials:

1. The ozone game rules per group of students.
2. The knowledge list on ozone.
3. The Teacher/Student background information on ozone.
4. Construction paper, scissors, rulers and markers per group of people.

### Focusing

1. Have the students use the ozone knowledge list to make a list of what they already know about the ozone layer and what they want to learn about the ozone layer.

### Finding out

1. Have the students play the ozone game. The teacher will need to explain how to play the game to the students from the teacher background information.
2. Have the students determine what part of the world they represented in the game by looking at the amount of ozone they had left.
3. When they have finished the game ask the students to write a summary on how ozone is made and destroyed and how it protects us.

### Bridging

1. Have the students design a new game representing the earth in the year 2050.
2. How is this game different from the one they played earlier?

## **Assessment**

1. The students will be able to identify how ozone is made and destroyed.
2. The students will be able to identify what parts of the world have the largest loss of ozone.
3. The students will be able to express what they think will happen to the level of ozone in the future through designing a game.

## Ozone Knowledge List

<b>What I know about the ozone layer</b>	<b>What I want to know about the ozone layer</b>

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# The O's Have It

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## Lesson 2

**Lesson Summary:** Students will identify current attitudes towards the ozone layer and what the public is willing to do to help protect the ozone layer.

**General Goal:** To introduce students to the various attitudes the public holds towards the ozone layer and then have them identify ways in which people are willing to help protect the ozone layer

**Duration:** 4 or 5 class periods lasting 55 minutes long.

### Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Explain the current knowledge level and the attitudes towards the ozone layer.
2. Identify what steps the majority of the public is willing to do to protect the ozone layer.

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# Teacher Background

The following background information on current EPA standards and laws that affect Ozone destruction have been provided in order for the teacher to explain or give students and idea on some current political opinions about the Ozone Layer and its destruction.

**To forecast the human consequences of global change at some point in the relatively distant future, one would need to know at least the following:**

- the future state of the natural environment
- the future of social and economic organization
- the values held by the members of future social groups
- the proximate effects of global change on those values
- the responses that humans will have made in anticipation of global change or in response to ongoing global change

## **Current EPA Standards**

- The current health and welfare-based ozone standards are both set at 0.12 parts per million (ppm), 1 hour average.
- The standards may not be exceeded more than once per year, on average over 3 years. The standards were last revised in 1979.

**EPA's new ozone standards will provide increased protection beyond that provided by the previous standard from the following effects:**

- Reduced risk of significant decreases (15% to over 20%) in children's lung functions (such as difficulty in breathing or shortness of breath), approximately 1 million fewer incidences each year, which can limit a healthy child's activities or result in increased medication use, or medical treatment, for children with asthma.
- Reduced risk of moderate to severe respiratory symptoms in children, hundreds of thousands of fewer incidences each year of symptoms such as aggravated coughing and difficult or painful breathing.
- Reduced risk of hospital admissions and emergency room visits for respiratory causes, thousands fewer admissions and visits for individuals with asthma.

- Reduced risks of more frequent childhood illnesses and more subtle effects such as repeated inflammation of the lung, impairment of the lung's natural defense mechanisms, increased susceptibility to respiratory infection, and irreversible changes in lung structure. Such risks can lead to chronic respiratory illnesses such as emphysema and chronic bronchitis later in life and/or premature aging of the lungs.
- Reduce the yield loss of major agricultural crops, such as soybeans and wheat, and commercial forests by almost \$500,000,000.

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# Lesson 2

## Activities

### Materials:

For each student copy the following materials:

1. Teacher/Student Ozone background information.
2. The students will also need to have library time and class time to gather current articles about the ozone.

### Focusing:

1. Have the students find five articles on the ozone. After locating the articles answer the following questions.
2. How easy were the articles to find?
3. Did some newspapers have more information than others?
4. In what section of the paper were the articles located?
5. After answering these questions what is your first impression about public interest in the ozone layer?

### Finding Out:

1. Have the students write a newspaper article giving their opinion on the five articles they collected.
2. Have them include their impression of how the public views ozone.
3. What was the main importance or viewpoint that each article stressed?

**Bridging:**

1. Have the student design an ozone questionnaire that they would use to gather information about public knowledge and attitude. These should have at least ten questions that are not yes/no questions. The questionnaire should also include things that people would be willing to do to protect the ozone layer, such as change all freon based equipment with other non harmful gases.
2. Have the students test these questionnaires out on each other first. Then have them use the questionnaire on 15 different people in their community.
3. Have each students write a newspaper article on the ozone layer with the questionnaire information.

**Assessment:**

1. The students will be able to identify the current knowledge and attitudes held by the public with regards to the ozone layer.
2. The students will be able to identify what the public is willing to do in order to protect the ozone layer.



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# The O's Have It

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## Lesson 3

**Lesson Summary:** Students will identify some of the impact people have already had on the ozone layer over the last 50 years. The students will then identify some of the health risks associated with the ozone loss.

**General Goal:** To introduce students to the history of the ozone layer and what impact humans have already had on it. The students will identify some of the health hazards associated with the decrease in the ozone layer.

**Duration:** 6 or 7 class periods lasting 55 minutes long.

### Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Explain what impact humans have had on the ozone layer.
2. Identify some of the health problems that have resulted in the loss of the ozone layer.

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# Teacher Background

The following background information on the History of the Ozone has been provided in order to help the teacher answer and guide student questions.

## History of Ozone

1939: German-Swiss chemist named Christian Schnobein discovers ozone.

1953: Valve for aerosol cans is developed by an American named Robert H. Abplanap. Uses Freon gases (a pollutant) for propulsion.

1958: U.S. scientists begin testing Earth's ozone layer to find out what effects have been caused by atmospheric testing of nuclear weapons and by the large amount of high-altitude flights by military and commercial jet aircraft that produce nitrous oxides (NO<sub>x</sub>). The ozone layer begins to increase over the next 13 years, but then began to shrink, possibly because of being broken up by chlorine gas released from Freon gas by ultraviolet rays in the atmosphere. Nearly a million tons of Freon is released into the atmosphere each year, mostly from aerosol cans, and environmentalists say that Earth's ozone is being depleted.

1977: Congress bans nearly all U.S. manufacture of aerosol products that use CFCs and Freon. However many countries do not do so.

1985: British scientist's report that a hole in the ozone layer is opening over Antarctica every spring.

1987: A meeting of nations in Montreal agree on measures to protect the environment and gradually ban CFC production. In December of that year researchers report a sharp decline in the amount of ozone from 1979 to 1986.

The following background information on ground-level ozone and its effects on health have been provided in order to help the teacher answer and guide student questions.

### **Ground-Level Ozone and Its Effects on Health**

- Ozone is the prime ingredient of smog in our cities.
- Ozone is not emitted directly into the air, but rather is formed by gases called nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs), which in the presence of heat and sunlight, react to form ozone.
- Ground-level ozone forms readily in the atmosphere, usually during hot weather.
- NO<sub>x</sub> is emitted from motor vehicles, power plants and other sources of combustion.
- VOCs are emitted from a variety of sources, including motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial sources.
- Weather patterns and periods of air stagnation contribute to yearly differences in ozone concentrations from city to city.
- There is increasing evidence that the percentages of environmentally significant trace gases are changing because of both natural and human factors.
- Ozone is a harmful pollutant that causes damage to lung tissue and.
- It is a powerful photochemical oxidant that damages rubber, plastic, and all plant and animal life.
- It also reacts with hydrocarbons from automobile exhaust and evaporated gasoline to form secondary organic pollutants such as aldehydes and ketones.
- The peroxyacyl nitrates are especially damaging photochemical oxidants that are very irritating to the eyes and throat.
- Photochemical oxidants are the most significant cause of agricultural loss in the United States.
- Ozone alone, or in combination with sulfur dioxide (SO<sub>2</sub>) and nitrogen dioxide (NO<sub>2</sub>), accounts for 90% of the annual crop losses in the U.S. that are caused by air pollution.
- Symptoms of breathing ground-level ozone include chest pain, coughing, nausea, throat irritation and congestion. It may also worsen bronchitis, heart disease, emphysema and asthma.
- Relatively low amounts of ozone can cause chest pain and coughing.
- The populations most at risk are those that spend time outdoors during the summer months in areas with high ozone levels, particularly if they engage in activities involving exertion. These include children at play and construction workers.
- Approximately 50 million Americans lived in counties with air quality levels above the Environmental Protection Agency's health-based national air quality standard for ground-level ozone in 1994.
- Ground-level ozone interferes with the ability of plants to produce and store food (e.g., starches), so that growth, reproduction and overall plant health are compromised.

- By weakening trees and other plants, ozone can make plants more susceptible to disease, insect attacks, and harsh weather (cold).

**When inhaled, even at very low levels, ozone can:**

- cause acute respiratory problems; aggravate asthma;
- cause significant temporary decreases in lung capacity of 15 to over 20 percent in some healthy adults;
- cause inflammation of lung tissue; lead to hospital admissions and emergency room visits [10 to 20 percent of all summertime respiratory-related hospital visits in the northeastern U.S. are associated with ozone pollution]; and impair the body's immune system defenses, making people more susceptible to respiratory illnesses, including bronchitis and pneumonia.

**Children are most at risk from exposure to ozone:**

- Children breathe even more air per pound of body weight than adults. Because children's respiratory systems are still developing, they are more susceptible than adults to environmental threats.
- Ground-level ozone is a summertime problem. Children are outside playing and exercising during the summer months at summer camps, playgrounds, neighborhood parks and in backyards.
- Asthma is a growing threat to children and adults.
- Children make up 25 percent of the population and comprise 40 percent of the asthma cases.
- Fourteen Americans die every day from asthma, a rate three times greater than just 20 years ago.

Ozone can aggravate asthma, causing more asthma attacks, increased use of medication, more medical treatment and more visits to hospital emergency clinics.

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# Lesson 3

## Activities

### Materials:

For each student copy the following materials:

1. Teacher/Student Background Information
2. Graphic organizer, Ozone Timeline - Past 50 years, for each student.
3. The Health Risk Associated with Ozone Loss sheet for each group of students.
4. Construction paper, colored pens, and ruler for each group of students.

### Focusing:

1. Have the students use the graphic organizer to write down what has happened to the ozone layer from the time aerosol cans were introduced to the most current information that was provided from the Teacher Background Information from lesson 1.

### Finding Out:

1. Have the students determine what type of actions have caused the most damage to the ozone layer.
2. Pass out the "Health Risk Associated with Ozone Loss" paper to each group of students.
3. Have the students, in groups, focus on one health issue and provide information for why the depletion of ozone would cause it.

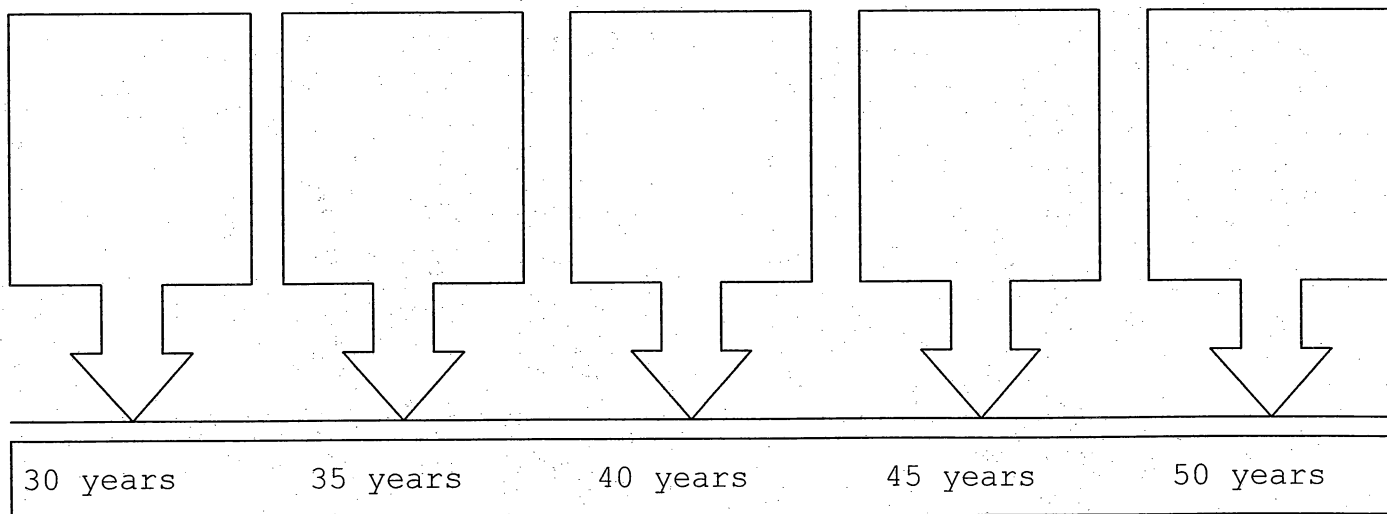
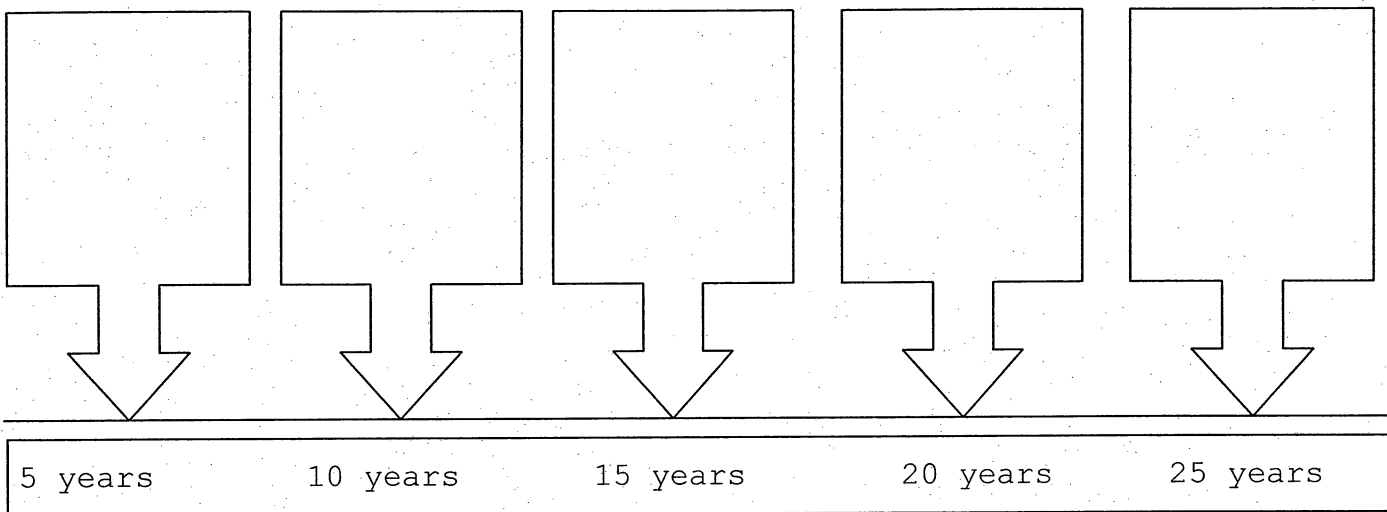
**Bridging:**

1. Have the students design posters for some product that will be needed in the future in order to protect people from the health problems caused by ozone depletion. Have them come up with catchy slogans for their product.

**Assessment:**

1. The students will be able to identify several ways humans have impacted the ozone layer.
2. The students will be able to identify a health risk associated with ozone loss.

**Ozone Timeline - Past 50 years**



## Health Risk Associated with Ozone Loss

Name of Health Problem: \_\_\_\_\_

Symptoms:

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Causes:

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Treatment:

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Are there any known cures? \_\_\_\_\_

Is this life threatening? \_\_\_\_\_

Can this disease decrease limit the person's activities?

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What are preventative steps that could be taken to reduce a person's risk of getting this?

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# The O's Have It

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## Lesson 4

**Lesson Summary:** Students will identify some of the impact people could have on the ozone layer in the next 50 years. The students will then identify some of the changes that could occur in their lifestyles because of these changes to the ozone layer.

**General Goal:** To introduce students to how humans could impact the ozone layer in the future. Then have the students identify some of the lifestyle changes that might occur in the future due to ozone depletion.

**Duration:** 5 or 6 class periods lasting 55 minutes long.

### Learning Objectives:

Upon completion of this lesson, students will be able to:

1. Explain what impact humans could have on the ozone layer in the next 50 years.
2. Identify some of the possible changes they will have to make in their lifestyles in the next 50 years.

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# Lesson 4

## Activities

### Materials:

For each student copy the following materials:

1. Graphic organizer, Ozone Timeline - The next 50 years, for each student.
2. "Changes in our Lifestyles" sheet.
3. Teacher/Student Background Information on ozone from lesson 3.
4. Construction paper, scissors, pens, magazines, and rulers.

### Focusing:

1. Have the students graph the changes that have occurred in ozone levels from the numerical information provided in the background information starting with 1960.
2. Using this information, at the current rate of depletion, have them extrapolate what the level of ozone would be in 50 years.
3. Have the students use the graphic organizer to write down what could happen to the ozone layer over the next 50 years by using the information from the graph.

### Finding Out:

1. Have the students make a list of changes that would occur in people's lifestyles, using the Teacher/Student background information, if the ozone depletion continues as predicted by the students graph.
2. How many changes in lifestyle would be needed compared to how people live today?

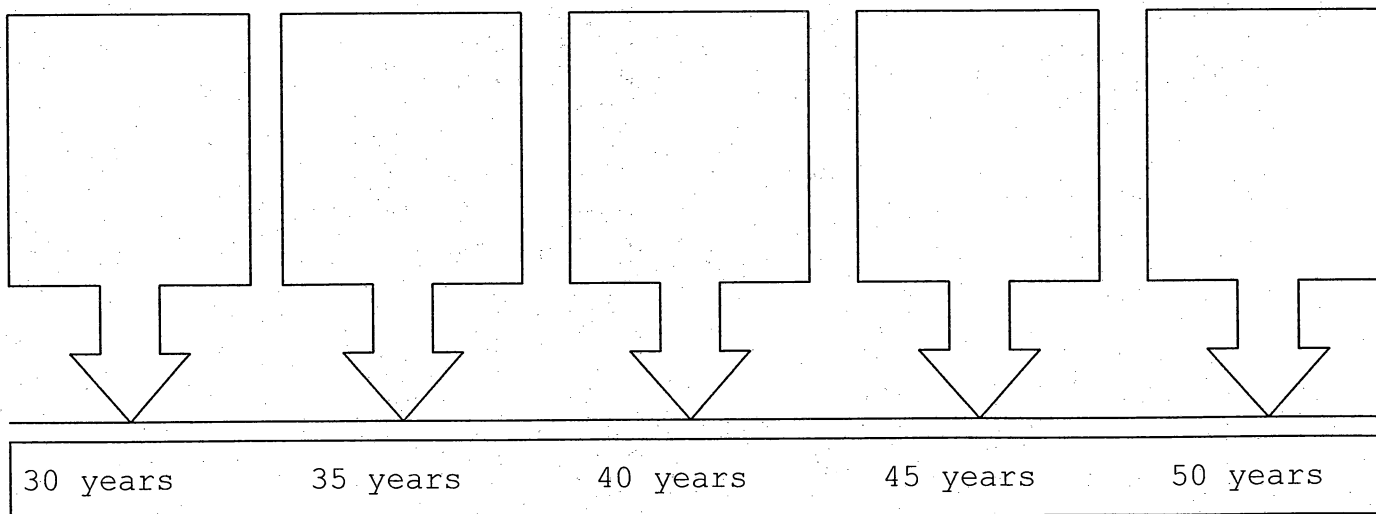
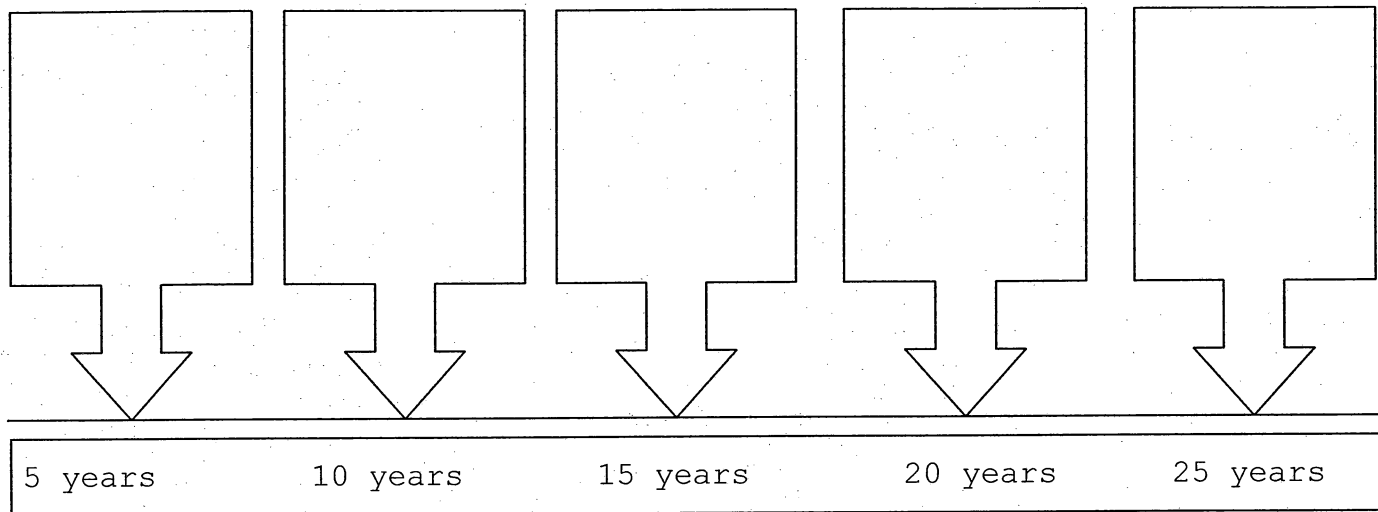
**Bridging:**

1. Have the students design a poster showing an outdoor recreation activity that they enjoy doing.
2. Have them design some sort of slogan for why the ozone layer is important in regards to the activity that they like to do.
3. The students will be able to place these posters around the school.

**Assessment:**

1. The students will be able to identify several ways humans could impact the ozone layer in the future.
2. The students will be able to identify several ways that the continual damage to the ozone will affect their lifestyles in the future.

Ozone Timeline - The next 50 years



**Changes in our lifestyles**

<b>With Ozone</b>	<b>With Reduced Ozone</b>	<b>No ozone</b>

## APPENDIX C

### Environmental Science Activity Guides

## Environmental Activity Resource Guide

### **Topic: Natural Resources**

Here is a list of the activity guides that can be used for the natural resource topics. Some are student ready resources and others are teacher resource guides that they can produce activities from.

**Subtopic: Water Quality**  
**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**  
**Title: Acid Rain, Opposing Juniors Viewpoints**  
**Address: Greenhaven Press Inc.**  
**Post Office Box 289009**  
**San Diego, CA 92198-9009**

This is an excellent resource guide on the opposing viewpoints for the issue of Acid Rain. The book is broken down into varying viewpoints centered on the issue of acid rain. Some of the issues are "is acid rain harmful" and "is acid rain harming animals". The book presents you with two opposing viewpoints and then provides information and facts to back up the two views. It also provides other views, usually about 4, of other issues dealing with acid rain. For each issue it provides facts and information for both sides of the argument and then allows the students to formulate their own opinion on the issue. A student ready guide.

**Subtopic: Water Quality**  
**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**  
**Title: Drinking Water, A Community Action Guide**  
**Address: Concern, Inc.**  
**1794 Columbia Road, NW**  
**Washington, DC 20009**  
**(202) 328-8160**

This action guide discusses the issues surrounding drinking water and its contamination. It looks at the laws for water pollution and the standards used to test water. What is considered an acceptable level or safe for drinking? It also discusses sources of ground water contamination and the process of cleaning water, or what it is cleaned for. It then covers the supply and conservation

issue and current federal legislation that affects drinking water. A student ready resource.

**Subtopic: Natural Communities**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Conservation Biology**

**Address: Center for Conservation Biology**

**Department of Biology Sciences**

**Stanford University**

**Stanford CA 94305-5020**

**(415) 723-5924**

This is a curricular resource that deals with the threats to biological diversity. This guide describes the cause/effect relationship of endangered animals and humans. It provides several lessons that focus on the problem of endangered species and what causes animals to become endangered. It presents alternatives to try and correct the problems. It also provides a great deal of background information that is very helpful to the teacher. It is a very good activity guide, which focuses on making students more aware of the how human activity causes animals to become endangered or even extinct. A teacher resource.

**Topic: Natural Communities**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Project WILD**

**Address: 5430 Grosvenor Lane**

**Bethesda, MD 20814**

**(301) 493-5447**

This is an activity guide that covers conservation, habitats, plants, human views and hopes to create awareness of our environmental problems. This resource guide is arranged by topic and grade level to help viewers find the information better. For each lesson it provides grade level it is most appropriate for, length of lesson, materials needed and extension ideas. The guide also provides lots of background information and identifies other activities that relate to the one that was done. It is an excellent activity book that help students become aware of the problems and issues, and also the students to take the information and make their own decisions about it. A teacher resource.



## Environmental Activity Resource Guide

### **Topic: Ecological Concepts**

Here is a list of the activity guides that can be used for the ecological concepts topics. Some are student ready resources and others are teacher resource guides that they can produce activities from.

#### **Subtopic: Groundwater**

**Age Group:** 7<sup>th</sup> -10<sup>th</sup> grade

**Title:** Groundwater, A Community Action Guide

**Address:** Concern, Inc.

1794 Columbia Road, NW

Washington, DC 20009

(202) 328-8160

The groundwater resource covers the topics of groundwater depletion in the United States, contamination of groundwater and health problems that arise from it. It then discusses how to detect contamination and then what we can do to monitor it. Then the federal role in protecting groundwater and what actions need to be taken are discussed. A student ready resource.

#### **Subtopic: Groundwater**

**Age Group:** 7<sup>th</sup> -10<sup>th</sup> grade

**Title:** Groundwater Education

**Address:** Water Education Foundation

717 K St. #517

Sacramento, CA 95814

(916) 444-6240

This resource discusses how groundwater is made and what aquifers do. It looks at types of contamination that enter our groundwater and how it effects wells, plants, livestock and humans. What can we do to protect our groundwater? This is the question that must be answered. A student ready resource.

**Subtopic: Teaching Soil and Water Conservation**

**Age Group: 9<sup>th</sup>-12<sup>th</sup>**

**Title: A Classroom and Field Guide**

**Address: U.S. Government printing office, 1992**

**No address provided**

**USBN: 0 317-138**

This book offers a brief but thorough introduction into soil science, including composition, the planet life cycles, pH, and the major and minor trace elements. A teacher resource.

## Environmental Activity Resource Guide

### **Topic: World Biomes**

Here is a list of the activity guides that can be used for the world biome topics. Some are student ready resources and others are teacher resource guides that they can produce activities from.

#### **Subtopic: Biomes**

**Age Group:** 7<sup>th</sup> -10<sup>th</sup> grade

**Title:** Project Learning Tree

**Address:** 5430 Grosvenor Lane

Bethesda, MD 20814

(301) 493-5447

Project Learning Tree has several lessons that address those issues of biomes. It looks at the effects humans have on the environment and the animals in the environment. Project Learning Tree provides excellent issues to involve the students and it provides lesson ideas for extension lessons. It provides a wide range of lessons that can be adapted to many age ranges and to many subjects. A teacher ready resource.

#### **Subtopic: Biomes**

**Age Group:** 7<sup>th</sup> -10<sup>th</sup> grade

**Title:** Project Aquatic

**Address:** 5430 Grosvenor Lane

Bethesda, MD 20814

(301) 493-5447

The activity resource presents materials to help students become aware of aquatic life and appreciate it. It then discusses the diversity found in aquatic areas and the importance of this diversity. The management and conservation of these areas are addressed and the impact that humans have had on the aquatic areas is also discussed. It then addresses the responsibility we have to these areas and what we can do to help stop the destruction of these areas. A teacher ready resource.

**Subtopic: Biomes**  
**Age Group: 9<sup>th</sup> -12<sup>th</sup> grade**  
**Title: Project Learning Tree, Focus on Forests**  
**Address: 5430 Grosvenor Lane**  
**Bethesda, MD 20814**  
**(301) 493-5447**

This is an excellent source of information for teachers to use in the classroom. It provides many lessons that are easily adaptable to a variety of curriculums. A teacher ready resource.

**Subtopic: Biomes**  
**Age Group: 9<sup>th</sup> -12<sup>th</sup> grade**  
**Title: Project Learning Tree, Forest Ecology**  
**Address: 5430 Grosvenor Lane**  
**Bethesda, MD 20814**  
**(301) 493-5447**

This activity guide covers 9 areas of forest ecology. It examines the ecological system in a forest, explores how forests are shaped and the role that humans have in maintaining them. Each section covers a particular topic and provides several lessons and activities that can be used in the classroom. A teacher ready resource.

**Subtopic: Biomes**  
**Age Group: 7<sup>th</sup> -12<sup>th</sup> grade**  
**Title: Botany for all Ages**  
**Address: The Globe Pequot Press**  
**138 West Main Street**  
**Chester, CN 06412**

This is an excellent guide with many ready to use lessons that can add to a study topic by giving them hands-on experiences. This guide also offers background information that is helpful for understanding the lessons. A teacher ready resource.

## Environmental Activity Resource Guide

### **Topic: Human Impact**

Here is a list of the activity guides that can be used for the human impact topics. Some are student ready resources and others are teacher resource guides that they can produce activities from.

**Subtopic: Population**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Population, Opposing Juniors Viewpoints**

**Address: Greenhaven Press Inc.  
Post Office Box 289009  
San Diego, CA 92198-9009**

This is an excellent resource guide on the opposing viewpoints for the issue of Population. The book is broken down into varying viewpoints centered on the issue of overpopulation. The book deals with issues of overpopulation, effects on humanity, worldwide resources, what causes overpopulation and interventions. The book presents you with two opposing viewpoints and then provides information and facts to back up the two views. It also provides other views, usually about 4, of other issues dealing with acid rain. For each issue it provides facts and information for both sides of the argument and then allows the students to formulate their own opinion on the issue. A student ready resource.

**Subtopic: Population**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Science Is**

**Address: Scholastic 1991  
123 Newkirk Road  
Richmond Hill, Ontario Canada, L4C 3G5  
(416) 883-5300**

This is a curricular resource book that covers the following areas: discovering science, matter and energy, humans, the environment, rocks, plants, living creatures, weather, the heavens, applying science. This book covers student's activities in a variety of areas. It provides a list of materials needed for the lesson, how to do the

lesson, and some interesting background information for the teacher and the students. Along with the student activities the book also provides an area of curricular resources divided into the same topics as the table of contents. The resource area runs from page 492 to page 509. The resource guide includes names of resources, where to order them from and a brief description of what they contain. A teacher ready resource.

**Subtopic: Global Climates**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Project Learning Tree**

**Address: 5430 Grosvenor Lane**

**Bethesda, MD 20814**

**(301) 493-5447**

Project Learning Tree has several lessons that address those issues of Human Impact and its affect on our environment. It looks at the effects pollution has on the environment and the animals in the environment. It looks at the effects of water pollution, air pollution and noise pollution. Project Learning Tree provides excellent issues to involve the students and it provides lesson ideas for extension lessons. It provides a wide range of lessons that can be adapted to many age ranges and to many subjects. A teacher ready resource.

## Environmental Activity Resource Guide

### **Topic: Environmental Ethics and Health Issues**

Here is a list of the activity guides that can be used for the environmental ethics and health issues topics. Some are student ready resources and others are teacher resource guides that they can produce activities from.

**Subtopic: Waste Management**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Pollution, Opposing Juniors Viewpoints**

**Address: Greenhaven Press Inc.**

**Post Office Box 289009**

**San Diego, CA 92198-9009**

This is an excellent resource guide on the opposing viewpoints for the issue of Pollution. The book is broken down into varying viewpoints centered on the issue of pollution. The book examines the cause/effect relationship of pollution and deals with air pollution, waste production, water pollution, and chemicals. The book presents you with two opposing viewpoints and then provides information and facts to back up the two views. It also provides other views, usually about 4, of other issues dealing with acid rain. For each issue it provides facts and information for both sides of the argument and then allows the students to formulate their own opinion on the issue. A student ready resource.

**Subtopic: Waste Management**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Toxic Waste, Opposing Juniors Viewpoints**

**Address: Greenhaven Press Inc.**

**Post Office Box 289009**

**San Diego, CA 92198-9009**

This is an excellent resource guide on the opposing viewpoints for the issue of Toxic Waste. The book is broken down into varying viewpoints centered on the issue of toxic waste. Some of the issues are "chemical companies and waste production and toxic waste and dumping in our oceans". The book presents you with two opposing viewpoints and then provides information and facts to back

up the two views. It also provides other views, usually about 4, of other issues dealing with acid rain. For each issue it provides facts and information for both sides of the argument and then allows the students to formulate their own opinion on the issue. A student ready resource.

**Subtopic: Waste Management**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Closing the Loop**

**18554 Haskins Road**

**Chargin Falls, OH 44023-1823**

**(216)-543-7303**

This activity resource guide discusses the problems of plastics in our environment, what landfills are and how they affect our environment, what happens if too many things are burned, the amount of energy and natural resources needed to produce consumer products and how recycling helps our planet. It discusses the theme of reduce, reuse, recycle and buy recycle. A teacher ready resource.

**Subtopic: Waste Management**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Waste, Choices for communities,**

**Address: Concern, Inc.**

**1794 Columbia Road, NW**

**Washington, DC 20009**

**(202) 328-8160**

This booklet discusses the problems of waste management. How does waste affect our environment and us? It discusses water pollution from leaching of dumpsites into groundwater. Air pollution is also discussed and its effect on health. With California being in the top ten for waste producers, waste should be a big concern. Recycling is looked at in this booklet and it also discusses current legislation on waste management. A teacher ready resource.



## APPENDIX D

### Environmental Science Resource Guides

## Environmental Science Resource Guide

### **Topic: Natural Resources**

Here is a list of the resource guides that contain addresses and telephone numbers along with pricing information for additional activity guides that can be used for the natural resource section.

**Subtopic: Water Quality**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: The Water Quality Catalog; A Source Book of Public Information Materials**

**Address: Water Pollution Central Federation  
601 Wythe Street  
Alexandria, Virginia 22314  
(703) 684-2400**

The water pollution central federation's public education committee developed this resource guide. This resource guide lists available resources information that are available in booklet form, books, guides, fact sheets, newsletters, pamphlets and brochures, slide shows, computer software, student activities and videos. The guide reviews each resource and lists where the resource can be acquired from and what the purchase price will be, if any. The resources deal with ground water, ponds, septic tanks, domestic wells, water quality, water conservation, clean coastal water, water pollution at home, the great lakes, timber harvesting and soil runoff in the water, pesticides in groundwater, interpreting ground water quality, freshwater wetlands, coal mining and many more. It is an excellent resource for locating materials dealing with the many aspects of water quality.

**Subtopic: Water Quality**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: The Catalog of Water Conservation, Public information materials**

**Address: California Department of Water Resources  
DWR's Office of Water Conservation  
P.O. Box 388  
Sacramento CA 95802  
1-800-952-5530**

The catalog was designed to provide an in-depth survey of current information already available on the topic of water conservation. The catalog identifies the type of resource, how much it is, if any, the number of copies you can get and whether you can reproduce it legally. It includes resources on awards, bookmarks, brochures, pamphlets, catalogs, certificates, coloring books, ditto sheets, information sheets, maps, movies, newsletters, program guides/manuals, software, students workbooks, teacher guides and many more. It has extensively covered the field of water quality and many of the overlapping fields too. It provides many resources at your fingertips.

**Subtopic: Natural Communities**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Compendium for Natural Communities**

**A cooperative presentation by:**

**The California department of education**

**The California integrated waste management board**

**The California department of toxic substance control**

**June 1993**

The compendium was organized in order to help educator's review and choose resources in the area of waste management. Available materials for grades 7-12 are reviewed from pages 85-141. The compendium covers wild life, the balance between conservation and development, conservation biology, watershed, wild life and people and world resources. Each of the curricular resources has a demonstration lesson in the guide. Each lesson identifies which subject matter it is most appropriate for, cost information, where to order the lesson guide form, and overall comments on how the panel of the compendium rated the activity guide. This is an excellent source of quick information on where to get resource material on waste management with an idea of the style in each guide.

## Environmental Science Resource Guide

### **Topic: Ecological Concepts**

Here is a list of the resource guides that contain addresses and telephone numbers along with pricing information for additional activity guides that can be used for the ecological concept section.

#### **Subtopic: Air Quality**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Minds on Science**

**Address: Harper Collins Publishers Inc.**

**10 East 53<sup>rd</sup> street**

**New York, NY 10022**

This resource addresses how to use the constructivist method to make all science issues more important to the student. It discusses the importance of environmental education and current movements to reform education. It discusses air quality, atmospheric conditions and the problems of acid rain. The ozone layer and green house affect and its current damage to the environment are also looked at. This is an excellent resource guide that is able to cover many topics of teaching and how to teach in the most effective way. It has many uses in the science field as well as others.

## Environmental Science Resource Guide

### **Topic: World Biomes**

Here is a list of the resource guides that contain addresses and telephone numbers along with pricing information for additional activity guides that can be used for the world biome section.

#### **Subtopic: Biomes**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Compendium for Human Communities**

**A cooperative presentation by:**

**The California department of education**

**The California integrated waste management board**

**The California department of toxic substance control**

**June 1993**

The compendium was organized in order to help educator's review and choose resources in the area of waste management. Available materials for grades 7-12 are reviewed from pages 66-169. The compendium covers the population, waste production and disposal, effects on the environment, food production, animal endangerment, food production, animal endangerment, energy, economics and environment and many more. Each of the curricular resources has a demonstration lesson in the guide. Each lesson identifies which subject matter it is most appropriate for, cost information, where to order the lesson guide form, and overall comments on how the panel of the compendium rated the activity guide. This is an excellent source of quick information on where to get resource material on waste management with an idea of the style in each guide.

#### **Subtopic: Plants and Animals**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Compendium for Natural Communities**

**A cooperative presentation by:**

**The California department of education**

**The California integrated waste management board**

**The California department of toxic substance control**

**June 1993**

The compendium was organized in order to help educator's review and choose resources in the area of waste management. Available materials for grades 7-12 are reviewed from pages 85-141. The compendium covers wild life, the balance between conservation and development, conservation biology, watershed, wild life and people and world resources. Each of the curricular resources has a demonstration lesson in the guide. Each lesson identifies which subject matter it is most appropriate for, cost information, where to order the lesson guide form, and overall comments on how the panel of the compendium rated the activity guide. This is an excellent source of quick information on where to get resource material on waste management with an idea of the style in each guide.

## Environmental Science Resource Guide

### **Topic: Human Impact**

Here is a list of the resource guides that contain addresses and telephone numbers along with pricing information for additional activity guides that can be used for the human impact section.

#### **Subtopic: Population**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Compendium for Human Communities**

**A cooperative presentation by:**

**The California department of education**

**The California integrated waste management board**

**The California department of toxic substance control**

**June 1993**

The compendium was organized in order to help educator's review and choose resources in the area of waste management. Available materials for grades 7-12 are reviewed from pages 66-169. The compendium covers the population, waste production and disposal, effects on the environment, food production, animal endangerment, food production, animal endangerment, energy, economics and environment and many more. Each of the curricular resources has a demonstration lesson in the guide. Each lesson identifies which subject matter it is most appropriate for, cost information, where to order the lesson guide form, and overall comments on how the panel of the compendium rated the activity guide. This is an excellent source of quick information on where to get resource material on waste management with an idea of the style in each guide.

## Environmental Science Resource Guide

### **Topic: Environmental Ethics and Health Issues**

Here is a list of the resource guides that contain addresses and telephone numbers along with pricing information for additional activity guides that can be used for the Environmental Ethics and Health Issues section.

#### **Subtopic: Waste Management**

**Age Group: 7<sup>th</sup> -10<sup>th</sup> grade**

**Title: Compendium for Integrated Waste Management**

**A cooperative presentation by:**

**The California department of education**

**The California integrated waste management board**

**The California department of toxic substance control**

**June 1993**

The compendium was organized in order to help educator's review and choose resources in the area of waste management. Available materials for grades 7-12 are reviewed from pages 51-92. The compendium covers the topics of integrated waste management, solid waste, recycling, household pollution, and hazardous waste. Each of the curricular resources has a demonstration lesson in the guide. Each lesson identifies which subject matter it is most appropriate for, cost information, where to order the lesson guide form, and overall comments on how the panel of the compendium rated the activity guide. This is an excellent source of quick information on where to get resource material on waste management with an idea of the style in each guide.



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